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Archives of PHYSICAL MEDICINE *and* REHABILITATION

INDEX/ABSTRACT ISSUE

ORIGINAL ARTICLES

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Editor of the Month

PAUL A. NELSON, M.D.

Cleveland

Archives of Physical Medicine and Rehabilitation

Code of Advertising

The *Archives of Physical Medicine and Rehabilitation*, published monthly by the American Congress of Physical Medicine and Rehabilitation, is interested in the maintenance of the highest standards in advertising in the interest of its readers in the medical and closely allied professions, the various manufacturers and patients. The *Archives of Physical Medicine and Rehabilitation* believes that honest, straightforward and informative promotion is essential in the merchandising of products and apparatus affecting the health and welfare of the general public. For this reason, the APM&R has formulated some basic principles to serve as a guide to manufacturers and advertisers.

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1. Claims for the efficacy or usefulness of a product should be logically and appropriately based upon scientific evidence or authoritative opinion expressed by qualified persons.

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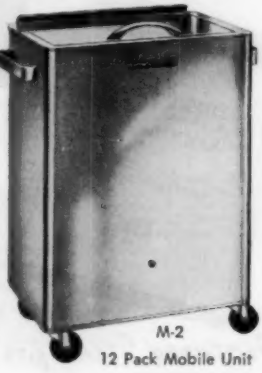

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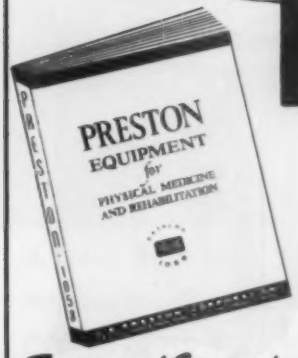

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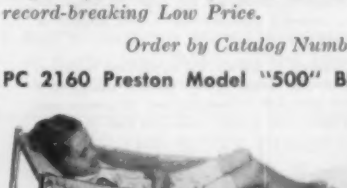

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Important Announcement —

The next examinations of the American Board of Physical Medicine and Rehabilitation will be held in Philadelphia, Pennsylvania, June 12 and 13, 1959. The final date for filing application is February 15, 1959. Write to the Secretary, Dr. Earl C. Elkins, 200 First Street S. W., Rochester, Minnesota, for application form.

Watch for the 14th Edition

of

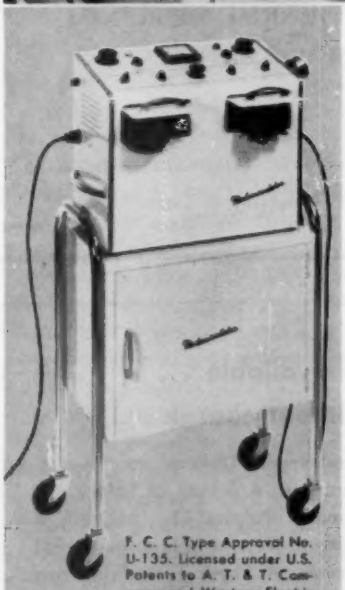
The Directory of the American Registry of Physical Therapists

In the January, 1959 Issue of the

Archives of Physical Medicine and Rehabilitation

Reprint copies of this edition of the Directory will be available in February, 1959.

The cost of the Directory which will contain an alphabetic and geographic listing of registrants is $2.50. Something new has been added to this issue. The geographic listing will carry the year of official registration of each physical therapist. Orders for this publication may be sent to American Registry of Physical Therapists, 30 N. Michigan Ave., Chicago 2, Illinois.



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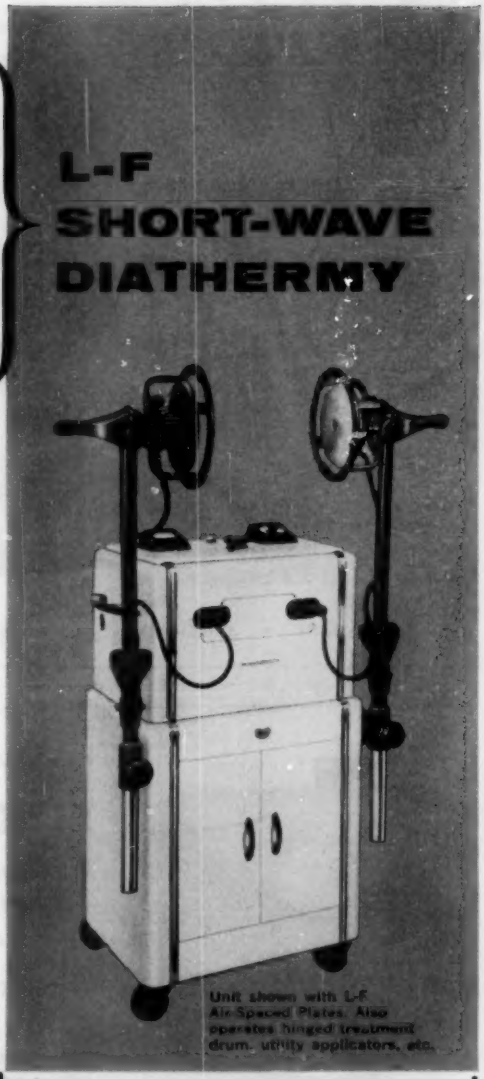

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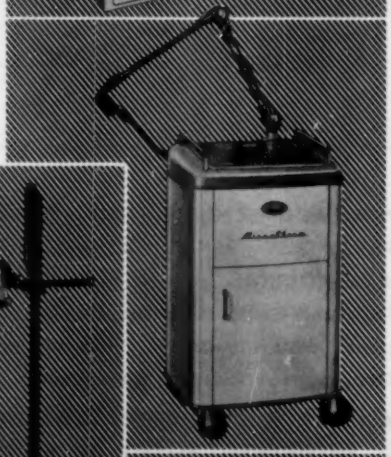

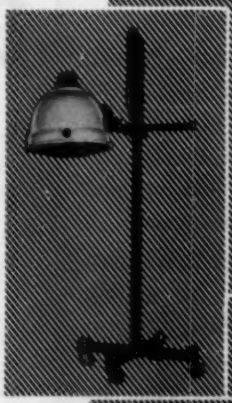

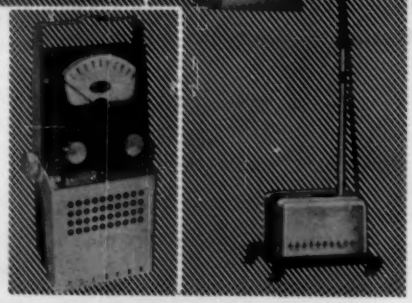

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extend to all members, readers, advertisers and friends, their very best wishes for a

Merry Christmas
and a
Happy New Year

The Eighth John Stanley Coulter Memorial Lecture: Training and Fitness—Concepts and Problems in Rehabilitation

Karl Harpuder, M.D.
New York

● Fitness for the handicapped and the aged can be defined in the same terms as for the average man with certain added limitations. Beyond clinical impressions, no data is available on how chronic arthritis, peripheral vascular disease or chronic neurologic disease interferes with physical performance and what training, mechanical aids and adjustments will do for physical ability and total functional fitness. The purpose of training for the aged and handicapped is to increase their functional fitness, their ability to handle activities of daily living and management of a suitable occupation. In this instance, training is not a purpose onto itself. It should be designed to prepare for these activities on an individual basis, take maximum advantage of experience and skill, and give due consideration to psychologic factors. Thorough investigation is needed of the metabolic, respiratory and circulatory effects of exercise, of the methods, limits and goals of training, and finally a detailed study of the physiologic effects of specific daily, recreational and occupational activities in specific disabilities.

The problems of fitness and training have mainly been studied by physiologists in athletes for maximum physical performance and maximum endurance. Obviously the standards of these studies cannot be applied without major changes to the average population living under the conditions of our present western civilization. This is even more so when we consider those handicapped because of residual chronic illness or disability or those in the older age group. Both categories are the concern of all in rehabilitation. The definition of athletic fitness is the ability to maintain or to regain homeostasis rapidly, which is dynamic metabolic and circulatory equilibrium during maximal physical effort usually measured in ml/kg per minute. Indices of fitness are among others the maximum O_2 intake per minute signalling the availability of aerobic energy and the lactate level of the blood signalling the need for and supply of anaerobic energy. The functional purpose of training for athletic fitness is superiority in athletic competition, survival under conditions of extreme physical hardship such as military service and the ability to perform extremely hard industrial work such as lumberjack or woodsman. Emotional and intellectual influences are usually not considered and are indeed in most instances adequately favorable and not a significant variable in athletic fitness.

Definition

The definition of fitness for average man in western civilization should be to maintain homeostasis during the common stresses of daily and occupational activities and regain metabolic equilibrium rapidly under the occasional and more severe stresses of every man's life. The functional purpose of training for the average man's fitness is complete and lasting independence in the activities of daily life and of occupational as well as economic usefulness. This involves preventive measures against disease wherever possible. Nutrition and hygienic habits become important variables. Emotional and intellectual factors have a decisive influence. However the availability of aerobic and anaerobic energy in relation to the requirements remains the physiologic basis of physical fitness, and is measured by maximum O_2 intake and blood lactate level. Maximum O_2 intake in the average is much lower than in the athlete.

Fitness for the handicapped and the aged can be defined in the same terms as for the average man, with certain added limitations. Either maximum O_2 intake is further diminished because of cardiorespiratory involvement or the energy cost of physical performance is increased because of neuromuscular disabilities, or both factors are combined to decrease physical efficiency. Examples are a person with emphysema, an amputee and a diabetic with arteriosclerotic heart disease and diabetic neuropathy.

Read at the Thirty-sixth Annual Session of the American Congress of Physical Medicine and Rehabilitation, Philadelphia, August 26, 1958.

Chief, Department of Physical Medicine and Rehabilitation, Montefiore Hospital; Senior Consultant, VA Hospital, Bronx.

Emotional and intellectual adaptability is much more important than in normals. It is sometimes necessary to use mechanical aids and adjustments of the environment to obtain the functional goals of training and fitness. Personal and environmental adjustments however cannot be limited to mechanical procedures. They involve, in many instances intellectual performance and psychologic reactions. These may play a dominant role for total functional fitness. It seems therefore necessary to extend the concepts of fitness for average man and for the handicapped beyond the four components usually enumerated for physical fitness, namely "strength, speed, endurance and coordination." The definition must also include emotional reactivity and intellectual performance thereby arriving at the concept of total functional fitness for personal and social goals.

However exact data are mainly available for physical fitness and training aspects. Findings in athletes are taken for comparison and reference points. Much of the material has been reviewed by Astrand[1] in 1956, and by Passmore and Durnin[2] in 1955. In work which does not require any special skill, maximum O_2 intake does not show great individual variations. Greatest values obtained in well-trained young athletes are slightly above 5 L/min or 70-80 ccm/kg body weight/min. Uphill running produced these values. They were combined with pulmonary ventilation rates of 120-140 L/min, cardiac rates of 180-200/min and blood lactic acid levels of 80-120 mg. per 100 ccm. They compare with resting values of 8-12 L of pulmonary ventilation, resting pulse rates of 50-70 and lactic acid levels of less than 15 mg. per cent. The cardiac output during heavy total body exercise increases from a resting 5-6 L to an estimated 30 L or more. The increase is due to a larger stroke volume of up to 170 ccm as well as the greater cardiac rate. There is some evidence that the larger stroke volume not only depends upon the greater return of blood to the right heart producing an increased end diastolic filling volume but also upon an improved systolic emptying thereby reducing the residual blood volume of the ventricles. The O_2 extraction from arterial blood in exercising muscles increases from a resting 6 vol. per cent to 13-14 vol. per cent, leaving in the venous blood 6-7 vol. per cent of O_2. Under extreme effort, especially in untrained persons, O_2 utilization may be nearly complete. The arterial O_2 content of 20 per cent vol. will then be reduced to 2 per cent vol. in the venous blood. In spite of this intensive desaturation and a very rapid blood flow through the lungs, pulmonary oxygenation is complete. Only under extreme conditions will physical effort cause a measurable decrease of arterial O_2 pressure and O_2 unsaturation.[3] It deserves emphasis and repetition, that the stroke volume in athletes remains increased at the high cardiac rates of 160-180 and more. Cardiorespiratory performance is further improved by a larger circulating blood volume and hemoconcentration.

Physical fitness also depends upon the mechanical efficiency of the muscle machine. Aerobic muscle work permits not only sustained effort but also apparently a more economic performance than anaerobic metabolism with lactic acid accumulation. The ability for a large O_2 intake increases mechanical efficiency. If the contraction energy is derived from carbohydrates, mechanical efficiency is assumedly greater than if fat combustion is the basis. The mechanical efficiency of contraction must not be mistaken for the efficiency of physical performance and work which depends on coordination and skill.

Training and Its Effects

Training for physical fitness consists of general muscle strengthening exercises and/or specific exercises to improve certain physical performances. One of the best known effects of training is the development of skill — carrying out a task with a minimum of muscle movement and effort. The result is improved metabolic and cardiorespiratory economy. Exercise with sufficient load produces hypertrophy of muscles and greater strength. Another probable local effect is

increased vascularity of muscles. Cardiovascular and respiratory effects of training are low resting cardiac rate and ability to increase it greatly; ability to increase stroke volume by improved systolic emptying; increased vital capacity; high minute volume of respiration during physical stress, and large circulating blood volume and upper limit hemoglobin levels. All of these factors elevate maximum O_2 intake leading to increased ability for aerobic steady-state work of high intensity and long duration. Resting levels of blood lactic acid are low, increase slowly under heavier loads than before training, but are tolerated at higher levels before signs of fatigue appear. Consequently, the anaerobic ability for maximum physical effort is improved.

If training is discontinued, its effects gradually disappear. It was found that when young healthy men step on and off a high bench, 30 such movements per minute were possible for only 1 minute, 50 seconds to 2 minutes, 40 seconds. After 17-33 days of training the performance was carried out for 15 minutes. A training interval of 13 weeks reduced this to 7 minutes, 3 seconds. If stepping were done with the right foot first during training and with the left foot first during testing, endurance was lowered from 15 to 4-5 minutes. This points out the importance of skill even in the simplest form of exercise.[4]

Training is usually carried out in several relatively extended exercise periods daily with increased loads. The periods do not necessarily consist of the same type of activity. First results are measured after 9-10 days; maximum benefits are obtained in 3-4 weeks. Observations have been recently reported that optimal increases in muscle strength can be obtained by static muscle contractions of 6-9 seconds duration with 2/3 maximum load, once daily.[5] Such exercises could not conceivably improve skill, maximum O_2 intake or the metabolism of lactic acid. The requirements for fitness training are not fulfilled, although hypertrophy of muscles and greater local muscle strength were recorded.

Sedentary life avoiding physical effort has the reverse effects of exercise. Deterioration of muscle strength, of skill, low maximal O_2 intake, rapid increase of cardiac rate under moderate effort with a limit of about 160 per minute before discomfort and lactic acid accumulation appears. In addition, sedentary life results often in weight gain or manifest obesity which decreases mechanical efficiency and raises the energy cost of exercise. Bed rest, especially in combination with disease or trauma causes a well-known and discussed metabolic deterioration, severe negative N-balance, loss of calcium, phosphate and sulfate, muscle wasting and osteoporosis.

In our culture, the automobile is required to get to the shop around the corner, the elevator to go down a flight of stairs and an intercom system to avoid moving about in an office. Food is plenty and rich and of a type which not only favors weight gain but possibly degenerative vascular disease. To maintain fitness, training procedures are required for normal man unless occupation provides sufficient physical stress.

With increasing age, probably in the third decade, the ability to withstand physical stress diminishes even for those who remain physically active and free of demonstrable disease. The physical downgrading is due to a reduction in cardiac and respiratory reserve. Observations in the same person showed at age 24, a vital capacity of 5.25 L with a residual air of 1.66 L, a maximum breathing capacity of 170 L and a maximum ventilation during work of 118 L/min. At age 75, the respective values were 3.2 L with 1.92 L residual air; maximum breathing capacity of 130 L and 48 L/min during work. O_2 uptake in ccm/kg body weight/min while running was 48.7 at age 24, and 25.5 at age 75.[6] Dill[7] in 1958, published data obtained on himself. At age 37, maximum O_2 uptake was 3.28 L with a pulse rate of 172; at age 66, 2.8 L with a pulse rate of 160. Running 9.3 km/h at age 41, his O_2 uptake was 2.13 L/min; at age 66, it cost him 2.8 L. However there was a gain of weight from 72.5 kg. to 80 kg. during the interval. There is then a

diminution in cardiorespiratory proficiency and mechanical muscular efficiency due to age and possibly gain in weight. The assumption is justified that these alterations are much aggravated if a sedentary life, obesity or subclinical vascular degeneration and pulmonary pathology is present. Obviously physical and occupational activities have to be adjusted to preserve and maintain "fitness of the aged." In a given case it may require expert medical observation and advice to delineate goals and measures.

The influence of disease upon fitness was studied among others by Simonson and his co-workers.[8] Any type of disease interferes with physical performance in some way. Pain plays a major role as was shown by Keys[9] in young volunteers during acute starvation experiments. In chronic semi-starvation, maximal O_2 intake is reduced by 25 per cent and the ability to produce lactic acid is also diminished. Static strength is lessened and sustained effort is difficult.

No data are available beyond clinical impressions how chronic arthritis, peripheral vascular disease or chronic neurologic disease interferes with physical performance and what training, mechanical aids and adjustments will do for physical ability and total functional fitness. This is an open field for study of very great importance for rehabilitation.

An increasingly important problem is offered by those who have residual cardiorespiratory disabilities. Myocardial infarcts and coronary artery disease is more evident in young people now. However, survival rate, duration and degree of recovery is improved. The increase in older age population and the resultant greater frequency of circulatory and respiratory disability is well known. Cardiac surgery will salvage many with rheumatic heart disease and congenital heart disease for rehabilitation and a useful life. Generally one must assume some reduction of cardiac and ventilatory reserve in such cases and start physical training with great circumspection. Careful attention must be given to cardiac and respiratory rate, blood pressure, signs of dyspnea and cyanosis, and evidence of general stress. Need for careful observation does not militate against an early and systematic program of physical rehabilitation in suitable patients. Beyond doubt an exercise regime will improve mechanical efficiency and skill and reduce the energy cost and the cardiorespiratory load of daily activities. Whether it is also possible to increase cardiac reserve and maximal O_2 intake is an unanswered question which urgently needs experimental study. According to Simonson, there are two important indices of cardiorespiratory efficiency during exercise. The adaption period comprises the first five minutes during which the cardiac shows a delayed increase of O_2 intake and CO_2 elimination. The oxidative recovery speed is the first phase of recovery during which O_2 requirement remains unchanged. The reduced cardiac reserve in cardiacs is compensated for by a delayed recovery time.

In orthopedic and neurologic disabilities with intact cardiorespiratory function, the energy cost of certain types of physical activity may be greatly increased. It is assumed by Gordon[10] that the mechanical efficiency of a swing-through gait in a paraplegic is only 4-6 per cent. The energy expenditure of an unilateral above-knee amputee walking on level ground with a monaxial knee joint prosthesis is 25 per cent above normal. At the same time circulating blood volume and stroke volume is likely to be diminished in relation to the reduced body surface and mass. According to Gordon, similar circulatory changes occur in paraplegics. These factors have to be considered when prescribing a training program.

The purpose of training for the aged and handicapped is to increase their functional fitness, their ability to handle activities of daily living and management of a suitable occupation. In this instance, training is not a purpose onto itself. It should be specifically designed to prepare for these activities on an individual basis, take maximum advantage of experience and skill, and give due consideration to psychologic factors.

The suggested definition of physical fitness of average man, including those

in the older age groups and those with handicaps, is to be permanently and completely independent in the activities of daily life and management of a suitable occupation. Neglecting emotional and intellectual factors, the suitability of an occupation depends upon its energy requirements. These vary with skill and experience of the operator and with environmental factors for example, the height of a work bench, the light distribution and ventilation of a room, etc. However average data are available for the energy cost of activities of daily living and of occupations. These need to be considered in training for fitness and planning for vocational rehabilitation. They have been reviewed in some detail by Passmore and Durnin in 1955. A few data may be mentioned here because of their general interest. The basal metabolic rate is about 1 Cal/min. Sitting and writing costs about 2 Cal/min standing at ease costs about the same. Walking with a body weight of 120 lbs. at 4 miles per hour costs about 5 Cal/min, but walking in snow at the same speed costs 12 Cal/min. Golfing costs 5 Cal/min, and dancing costs about the same. Housework averages 4-5 Cal/min. Typewriting and watch repair consume 1.5 Cal/min; tailoring 2.7-4 Cal/min; machinists work 3 Cal/min; agriculture 7 Cal/min, and timber cutting 11-12 Cal/min.

In an industrial occupation 12.5 Cal/min means extremely heavy work. Very heavy work requires 10 Cal/min; heavy work over 7 Cal/min; moderate work over 5 Cal/min, and light work more than 2.5 Cal/min. No occupational effort is maintained without rest pauses. A gross overall of about 5 Cal/min for 8 hours is considered endurance limit.

These figures are averages obtained in healthy young men. Variations due to habits and skill, facilities, age and sex have been extensively studied at the Max Planck Institute.[11] Obviously these data have limited value in dealing with the handicapped and older age groups.

We need thorough investigation in these groups of people of the metabolic, respiratory and circulatory effects of exercise, of the methods, limits and goals of training, and finally a detailed study of the physiologic effects of specific daily, recreational and occupational activities in specific disabilities. This is applied physiology of rehabilitation. It is as basic as applied physiology in internal medicine and as essential as the appreciation of psychologic and intellectual problems in rehabilitation. It is a fundamental field of rehabilitation research necessary for further scientific and clinical progress and development.

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Influence of Surgical Metal Implants on the Distribution of the Intensity in the Ultrasonic Field

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● The acoustic properties of metals used for surgical implants have been investigated, and it has been found that a large amount of ultrasonic energy is reflected at the tissue-metal interface. This leads to the establishment of patterns of standing waves in front of the implants and to focusing. The increase of intensity in the focal area has been measured and found to be appreciable. Further investigation seems to be necessary to determine whether or not the increase in intensity produced by the presence of surgical metal implants could lead to overheating of certain areas in the tissues.

Surgical metal implants and metal joint prostheses are commonly used in treatment of fractures and joint diseases. Many such conditions are frequently accompanied by the development of joint contractures, which are difficult to combat. The use of deep heating procedures would be very helpful in such conditions. Unfortunately, the use of short wave and microwave diathermy is contraindicated in most of these cases as the metal implant itself, or the tissues in the vicinity of the implant, may become overheated.

It seemed to be worthwhile to investigate whether ultrasound could be used as an efficient deep-heating agent to treat joint contractures even in the presence of surgical metal implants. This question arose since ultrasound has been used successfully to increase the range of motion in some joints.[1] In addition, experimental investigations have demonstrated that it is possible to heat selectively such fibrous tissues as are found in tendons, myofacial interfaces, and scars. The rise in temperature results in increased stretchability of the fibrous tissue.[2, 3]

The possibility of reflection of ultrasonic energy at the metal implant had to be considered in the investigation. Such reflection could result in focusing of ultrasonic intensity in such a fashion that "hot spots" could develop with resulting overheating of the tissues. It also had to be determined whether the metal implant itself would be selectively heated.

To answer these questions experimentally, it was necessary to determine the acoustic properties of the metals used in the implants and to compare them with those of the tissues. The change in distribution of intensity resulting from the presence of the implants had to be studied. Finally it was necessary to quantitatively assess the possible increase in intensity in the tissues.

Methods

The acoustic properties of the metals used in surgical implants were measured with the ultrasound transmission test set.[4] All measurements were made with an ultrasonic frequency of 0.97 megacycle per second and at a temperature of 37 C. The distribution of ultrasonic intensity in the field with and without the presence of the various types of metallic implants commonly used in surgery was made visible by the Schlieren method.[5] The increase of intensity in focal areas was measured with calibrated thermocouple probes.

The ultrasonic generator used in these experiments operated with full wave rectification at a frequency of 1 megacycle. The radiating surface of the applicator was 12.5 cm.[2*] The ultrasonic field in front of the applicator was mapped carefully with a sensitized thermocouple probe. The distribution was essentially the same as described.[4] All measurements in this study were performed in the far field. In the experiments an

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*The Generator, model 2A was supplied for this study by the courtesy of the Dallons Laboratories, Inc., Los Angeles.

aquarium filled with degassed water was used. The development of standing waves, ordinarily resulting from reflection of ultrasound by the walls of the aquarium, was prevented by the use of brush absorbers.

Experiments

In the first series of experiments an attempt was made to determine the acoustic impedance of the metals used in surgical implants. The acoustic impedance is ρc when ρ is the density of, and c is the sound velocity in the material. It was anticipated that it would be possible to estimate the approximate amount of ultrasonic energy reflected at the interface between the tissue and the metal implant by comparing the acoustic impedance of the metals with that of the tissues. It was also hoped that information might be obtained as to whether the metal implants would produce focusing of the ultrasonic energy. Finally, it was expected that it would be possible to estimate the amount of ultrasonic energy absorbed by the metal implants.

Table 1: Densities of Metals Used as Metallic Implants

Stainless Steel (A.I.S.I. No. 304)	8.02 g./cm.^{3}
Vitallium	8.29 g./cm.^{3}
Titanium	4.5 g./cm.^{3}

Table 1 shows the densities of the metals commonly used in surgical implants. The attenuation of the ultrasound in the metals and the sound velocity was determined indirectly, since a variable amount of ultrasonic energy is reflected, depending upon the geometry of the metal implant.

In a simplified case of a metal plate with a sound beam incident at an angle of 90 degrees the reflection can be calculated as follows:

$$R = \frac{\left(\frac{\rho_1 c_1}{\rho_2 c_2} - \frac{\rho_2 c_2}{\rho_1 c_1}\right)^2}{\left[4\,\mathrm{ctg}^2\,\frac{2\pi d}{\Lambda_2} + \left(\frac{\rho_1 c_1}{\rho_2 c_2} + \frac{\rho_2 c_2}{\rho_1 c_1}\right)^2\right]}$$

where R is the ratio of reflected to incident energy, ρ is the density, c is the sound velocity, d the thickness of the plate, and Λ the wave length.[6] Sub 1 refers to the surrounding medium, sub 2 to the metal.

From this follows that the amount of ultrasonic energy reflected at the metal plate will critically depend on the thickness of the plate. There will be minimum of reflection whenever the plate has a thickness equal to an even multiple of the quarter wave length of the sound in the metal. That means, the distance between two minima of reflection will be equal to one-half wave length. This fact was utilized in order to determine experimentally the wave length in titanium and stainless steel (fig. 1). Thus the

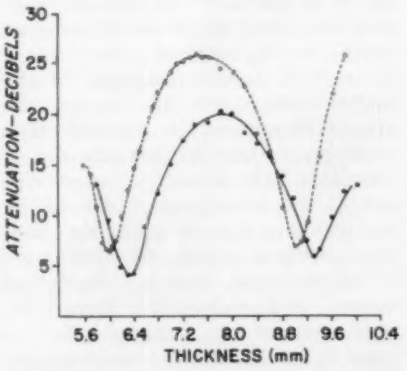

Fig. 1 — Attenuation of ultrasound at various thickness of stainless steel (o - - - o) and titanium (• - - - •) discs. The diameter of the titanium disc was 25.5 mm., and the diameter of the stainless steel disc was 51 mm.

wave length of ultrasound in titanium was found to be 0.59 and in stainless steel 0.604 cm. The sound velocity was calculated according to the formula $\Lambda = \frac{c}{n}$, where n is the ultrasonic frequency. Thus, the sound velocity in titanium is 5,723 m./sec. and in stainless

steel is 5,858 m./sec. Therefore, the acoustic impedance ($\rho \cdot c$) of titanium is $2.575 \cdot 10^6$ g./cm.^{2} sec. and of stainless steel is $4.699 \cdot 10^6$ g./cm.^{2} sec. Previous measurements have demonstrated that the acoustic impedance of soft tissues, such as muscle, is of the order of $1.667 \cdot 10^5$ g./cm.^{2} sec. and that of cortical bone is of the order of $4.459 \cdot 10^5$ g./cm.^{2} sec.[4] It becomes apparent that there is a marked mismatch between the impedance of metals used in implants and that of tissues. Therefore, a marked reflection can be anticipated at the interface of the metal implants and the tissues. Finally, it can be assumed that the acoustic properties of vitallium are similar to those of the metals measured.

The amount of absorption in the metal can be estimated by the attenuation in those discs where minimum reflection occurred, that is, when the discs have a thickness of an even multiple of the quarter wave length. In this case, the amount of reflection is minimal. The remaining attenuation is largely due to absorption. (It should be noted that part of the attenuation is due to the fact that in a disc not all of the ultrasonic energy is propagated in the form of compressional, that is, longitudinal waves.) As demonstrated in figure 1, the attenuation of the ultrasound by the metal due to absorption is small as compared with the attenuation resulting from reflection. The absorption in the metal is of the same order of magnitude as that in tissues.[7-9] Thus, a reflection of temperature in the metal implants as a result of selective absorption of ultrasonic energy cannot be expected.

Thus, it could be anticipated that the major problem encountered in medical implants would result from reflection. The amount of reflection will critically depend on the kind of metal used in the implant. Reflection can produce patterns of standing waves in front of a metal plate and this can lead to an increase of the ultrasonic intensity. Reflection can also lead to focusing.

In the second series of experiments an attempt was made to determine whether such focusing or standing waves were actually produced when the surgical metal implants were present in the ultrasonic field. Since the acoustic impedance of water at a temperature of 37 C. is similar ($1.522 \cdot 10^5$ g./cm.^{2} sec.) to that of soft tissue ($1.667 \cdot 10^5$ g./cm.^{2} sec.)[4, 7] it seemed to be justified to study the pattern of ultrasonic intensity resulting from reflection at the metal implant in a water bath. The distribution of ultrasonic intensity was demonstrated with the Schlieren method, and the change in the intensity distribution in the field was studied after various metal implants were inserted. The following implants were used: bone screws and plates of various sizes, the Thornton side plate, a Smith-Peterson nail, a Küntscher nail, a Hegge pin, suture wires, vitallium hip cups, an Eicher prosthesis, and the Hanson-Street intermedullary nail.

Results are shown in figures 2-7. The implants not shown in these figures showed little or no focusing, but almost invariably a pattern of standing waves in front of the implant and sometimes scattering.

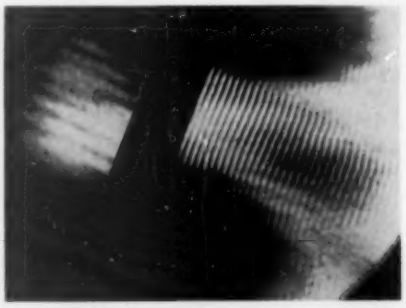

Fig. 2 — Pattern of standing waves in front of a reflecting stainless steel plate. The upper beam incident at the plate, lower beam reflected at the plate. On the left of the plate is the transmitted beam.

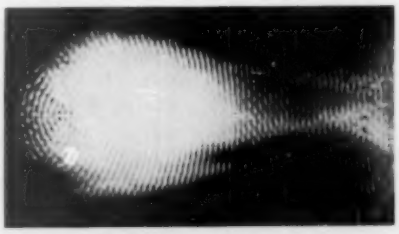

Fig. 3 — Focus within a vitallium cup on the left, beam incident from the right. Note also the pattern of standing waves.

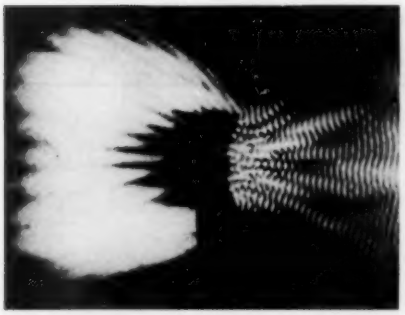

Fig. 4 — Pattern of standing waves and increase of intensity between flanges of a Smith-Peterson nail. Ultrasound beam incident from the right.

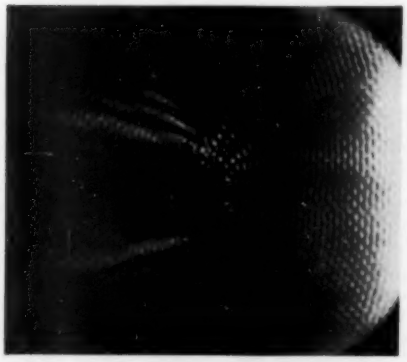

Fig. 5 — Smith-Peterson nail: pattern of standing waves in front of nail when flange of nail points toward the surface of the applicator on the right.

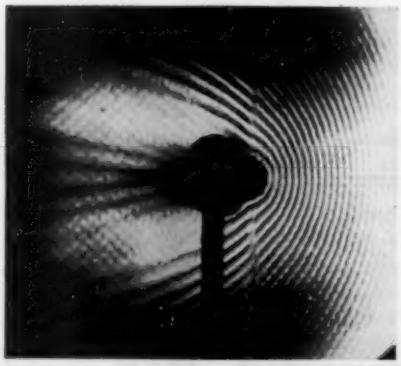

Fig. 6 — Pattern of standing waves and distortion of the sound field created by the presence of the Küntscher nail.

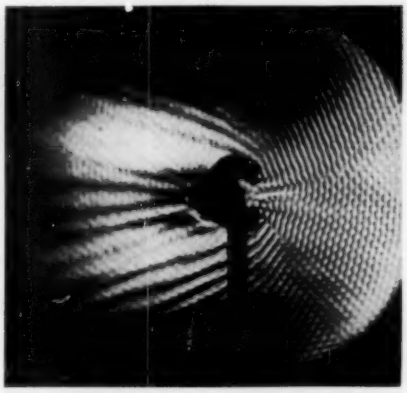

Fig. 7 — Pattern of standing waves in front of the Küntscher nail, increase of intensity within the groove of the nail. Sound beam incident from the right.

In order to determine the increase of ultrasonic energy in the area of the focus or in the standing waves, measurements with a sensitized thermocouple probe were performed. The results of these measurements are summarized in table 2. It becomes apparent that an appreciable increase of the ultrasonic intensity can occur in front of the metal implants as a result of reflection and focusing. Very little ultrasonic intensity passes through the metal implants.

Summary

The acoustic properties of metals used for surgical implants have been investigated, and it has been found that a large amount of ultrasonic energy is reflected at the tissue-metal implant surface. This leads to the establishment of patterns of standing waves in front of the implants and to focusing. The increase of intensity in the focal area has been measured and found to be appreciable. Whether or not this, in turn, will lead to a selective rise of temperature in tissues depends on other factors, such as the dissipation of heat through conduction and convection, the specific heat of the metallic implants and of the surrounding tissues, and the amount of ultrasonic energy absorbed by the overlying tissues. Therefore, further investigations seem to be necessary to determine whether or not the increase in intensity produced by the presence of the surgical metal implants

Table 2: Change of Ultrasonic Intensity Resulting from the Presence of Metallic Implants

Type of Metal Implant	Mode of Application of Ultrasound and Location of Probe	Factor by Which Ultrasonic Intensity Is Changed (Mean Value)	Standard Deviation of the Mean
Stainless steel disc	Probe in front of disc, ultrasound beam incident at angle of 90°.	1.9	± .06
Stainless steel disc	Probe behind disc, ultrasound beam incident at angle of 90°.	0.03	± .022
Vitallium hip cup (diameter 5 cm.)	Ultrasound beam incident perpendicularly at opening of cup, probe in focal area.	6.2	± .10
Vitallium hip cup (diameter 5 cm.)	Ultrasound beam incident at convex side of cup, measurements within cup.	0.086	± .007
Vitallium hip cup (diameter 5 cm.)	Ultrasound beam incident at side of cup, measurements within cup.	0.1	± .00
Vitallium hip cup (diameter 3.1 cm.)	Ultrasound beam incident perpendicularly at opening of cup, probe in focal area.	6.4	± .06
Smith-Peterson nail	Ultrasound beam incident between 2 flanges of the nail, probe in focal area.	2.7	± .07
Smith-Peterson nail	One flange pointing toward ultrasound applicator, probe in focal area.	1.1	± .001
Kuntscher nail	Ultrasound beam incident at groove of nail, probe in focal area.	3.7	± .18

could lead to overheating of certain areas in the tissues.

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Some Medicolegal Aspects of Physical Medicine and Rehabilitation

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● This paper points out the ever-growing interrelationships between law and the specialty of physical medicine and rehabilitation. It is divided into three parts: 1. A brief discussion of applicable features of medical jurisprudence; 2. liability and responsibilities of physicians and other personnel of the departments within hospitals as well as legal implications of procedures and equipment employed, and 3. the insurance aspects which deal with medical reports, cooperation with statutory and administrative bodies such as Workmen's Compensation Boards, Rehabilitation Commissions, etc., and the evaluation of physical disability for purposes of litigation, settlements, or testifying in courts.

Today the total care concept of medical rehabilitation demands that the rehabilitation physician be aware of the administrative and socioeconomic factors which affect the medical progress of the patient's treatment. The great majority of these patients have chronic degenerative diseases. These include arthritis, cerebral vascular disease, and various muscular and nerve disorders resulting in locomotor difficulties including paraplegia, amputation, and traumatic disabilities. The physiatrist, a specialist in physical medicine and rehabilitation, has an increasing responsibility as more facilities and personnel are made available to him to direct and consult on the management of the medical care and disposition of these patients. Therefore, he comes in contact with medicolegal aspects frequently.

Medical jurisprudence or legal medicine is that branch of knowledge which applies the science of medicine and allied sciences to the service and administration of law and justice.[1] The common area between medicine and law is enlarging as the society in which we live becomes more complex and technological.

Medicine deals with the human body and the reaction of its intricate parts to the environment within and without; the law, however, deals primarily with the relationship between individuals or groups of people. These relationships are determined by custom or "mores," legislative enactments, the stare decisis of higher court decisions, and the rulings of quasi-judicial bodies, all of which, of course, reflect the so-called prevailing law of the land.

The following represents an outline of the broad field of legal medicine used by the authors in cataloguing information and in teaching.[2]

I. MEDICAL ORGANIZATION
1. State licensure: Official governmental certificates.
2. Medical organization relationships: American Medical Association, local medical societies.
3. Other special medical societies and groups; specialty groups.
4. Hospital administration and management: staff functions and responsibilities.
5. Medical economics: private practice v. group practice; physicians's tax problems; corporate practice of medicine.

II. CRIMINAL LAW
1. Forensic psychiatry: insanity and mental disease; sex crimes; treatment of criminally insane; prevention of crime; juvenile delinquency.
2. Forensic pathology: coroner and medical examiner system; investigation of homicides; toxicology.
3. Law-enforcement agencies.

III. INSURANCE-CIVIL LAW
1. Casualty insurance or accident insurance: personal injury; institutes and postgraduate education for doctors and lawyers; evaluation and extent of traumatic injuries; medical testimony — the doctor in the courtroom; workmen's compensation; rehabilitation programs.
2. Professional relations, doctor-patient relationship—malpractice —physician and hospital liability.

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3. Accident and health, hospitalization, life insurance: the definition of risk; hospitalization programs; law of contracts, defining disease patterns.

IV. PUBLIC HEALTH AND INDUSTRIAL MEDICINE

1. Broad planning for prevention of disease, safety and health programs; integration of law and medicine in such matters as automobile safety, industrial accidents.
2. Legislation designed to affect medical affairs. Food and drug laws; social security, etc.
3. Occupational medicine; medical supervision in industry.

As physicians we may deal with many of the subjects in this outline. With special regard to physical medicine and rehabilitation, certain topics are of more importance and interest. These lie in Section III — Insurance-Civil Law — and are as follows: professional liability; evaluation disability; rehabilitation programs.

A. *Professional Liability.* Malpractice and professional liability is always of concern as hospitals and physicians are being sued more frequently. Keep in mind that a person may always be held liable for his own torts (civil wrongs) or wrong doings. However, physicians in this field under the doctrine of respondeat superior may likewise be responsible for the injuries caused by their agents or employees. Thus, the relationship of the numerous personnel in rehabilitation departments or physical medicine clinics has to be analyzed in each individual negligence action. Likewise, whether the physician is an independent contractor or an employee of a hospital or corporation has to be ascertained. The status of these relationships of all the parties concerned in any particular incident is a factor in determining the ultimate question of liability.

A simple formula used to substantiate a malpractice cause of action consists of the four "D's" which the plaintiff or injured party must prove: (1) duty, to conform to a standard of conduct for the protection of others against unreasonable risk; (2) dereliction, breach of duty or failure upon the part of the physician to exercise that reasonable and ordinary degree of learning, skill, and care commonly possessed and exercised by reputable physicians practicing in similar localities; the physician must exercise his best judgment at all times; (3) direct cause, legal or proximate cause of the injury, of course, is the crux of the legal problem in many of these cases;[3] (4) damages, injury to the plaintiff.

When all four of these elements are established there is a so-called prima facie case.[4] The defendant physician or hospital then has available another "D": defenses such as assumption of risk, contributory negligence, etc.

In addition to negligence actions, occasionally suits are brought for false imprisonment, defamation-libel and slander, fraud and deceit, and assault and battery.

The physiatrist is especially vulnerable because he usually prescribes exercise and manipulations and the use of instrumentalities which, if not properly handled, can easily inflict some damage to a person. Prescriptions should be in writing, specific as to dosage and duration, with limitations clearly defined. The purposes and methods of treatment should be spelled out.

The common types of injuries result from the following:

1. Burns from diathermy or other heating devices and ultraviolet machines.
2. Electric shock from the various currents applied.
3. Mechanical injuries due to equipment present or absent in the department causing trips, falls, etc.
4. Injuries from manipulations or other therapy technics.

In general, the following preventive measures are apropos for physical medicine and rehabilitation clinics and departments, and apply to the physician and other medical personnel:

1. Observe helpless patients with the utmost care. Special precautions for the disabled, aged, and infirm types of patients.
2. Do not leave a patient unattended.

3. Heed any complaints of any patient with regard to pain or discomfort. Be especially aware of any sensory disturbances in the patient.
4. Check all patients before and after treatment.
5. Exercise care in the transport of patients.
6. Inspect carefully and systematically all apparatus in the department.
7. Test the apparatus routinely for safety.
8. Have properly trained, alert, loyal, and well-supervised therapists.
9. Maintain complete and legible hospital and clinical records.
10. Refrain from making improper and damaging statements with regard to treatment and disease unless authorized to do so.

B. *Evaluation of the Disability.* The physiatrist plays a major role in the medical evaluation and treatment of injury and disability. Clinical evaluation, joint range of motion, and muscle testing records are important. He also uses electrical diagnostic technics such as electromyography and quantitative tests of electrical excitability which are of increasing importance in evaluating many neuromuscular conditions.[5] The courts recognize electrodiagnostic technics as an important aid to determine the extent of injury. Traumatic or personal injury cases usually have an element of potential muscle or nerve injury. Most litigation in the courts today deals with personal injury. The physiatrist often goes to court to testify and should become familiar with legal procedures. Good reports of medical evaluation not only reflect the ability of the physician, but also the efficiency of any rehabilitation service. They are also the basis for logical, accurate, and factual expert scientific testimony. These should be objective and impartial.

At the Massachusetts General Hospital we routinely see many industrial and accident cases and are perfecting these electrical and other technics for evaluating disability.

Compensation presents a problem in the course of diagnosis and treatment of many patients, especially with regard to minor injuries and disabilities.

The authors do not agree with the physicians who either disregard the compensation factor or refuse to treat the patient until the compensation has been either paid or refused. We use a more direct approach and believe a comprehensive rehabilitation program must deal with these compensation factors and their interference with medical treatment by recognizing the same, discussing the matter with the patient, his family, and, if necessary, his legal advisors. Sometimes psychiatric and psychological consultation is utilized to overcome compensation anxiety.

Disability is not always synonymous with lack of ability. We at the Bay State Medical Rehabilitation Center and on the rehabilitation service at the Massachusetts General Hospital are developing methods to test physical abilities on the job as a guide to vocational rehabilitation. It is better to think in terms of physical ability rather than disability. Most rating methods used today are complicated and do not evaluate the functional abilities of the patient. The fact that one third of a finger is missing or that there is inability to flex 30 degrees does not tell us what functional use is still available, although from a rating standpoint one might say there is some degree of permanent and total disability.

Our method of evaluating patients with permanent disability is illustrated by the following where "ability" rather than disability is emphasized.[6]

Case 1. A 39-year-old man taken ill at the age of 16 with bone and joint tuberculosis was treated in a state sanitorium for three years. He had out-patient follow-up care until 1952, at which time the disease was considered stationary, but he had never been able to work and so was placed on disability assistance on public welfare. His physical disability was ankylosis of his spine, left hip, and left knee and limited motion in the right hip and knee. He was referred to this Clinic in May, 1955, for rehabilitation. Evaluation of his assets revealed that he was completely independent in the activities of daily living. His physical capacities were limited but he showed *"ability"* to lift 10 pounds and to carry 10 pounds. He had limited reach of his shoulder on the left,

but was able to sit on a high stool. He could walk with crutches long distances and around the room without external aid. He could not, of course, do any other more difficult locomotive performances.

In occupational therapy it was found that he had good *"ability"* in fine fingering activities; also he was *"able"* to handle messages over the telephone very well and accurately. He was tried out in the hospital instrument shop where he had above-average output. He was free from error, completely reliable, and willing. He showed considerable interest and eagerness in his work. He seemed to learn well and made good use of his new knowledge. His personality was described as pleasing, he was accepted by the group, and was always congenial and cooperative.

Psychometric tests revealed that he had an I.Q. of 118, which is bright-normal. His father was dead and his siblings were out of the home. He was living alone with his mother. He showed not too much initiative and it was felt that he would need considerable guidance in placement. He was accordingly referred to a vocational counselor, who observed his excellent hand-to-eye coordination and dexterity. He was accordingly placed in an electronics firm in Somerville where, sitting on a high stool, he used an angle binocular microscope. He started work in August, 1955, at a rate of 80 cents an hour. Since that time he has improved to such an extent that he is now receiving $1.25 an hour. Follow-up visits indicate that he is well received and doing well in spite of a severe physical handicap.

Case 2. A 37-year-old truck driver struck a steel bridge and was hospitalized and treated at the Massachusetts General Hospital, 1955, for the following injuries: fractured skull, laceration of knee, fractured sternum and ribs, dislocation of left shoulder, and a supracondylar fracture of the right femur.

After discharge he received physical therapy treatments and was then referred to the Bay State Clinic for further rehabilitation in June, 1956. At that time the right knee lacked full extension by 5 degrees and flexion to 100 degrees. The quadriceps was atrophied. Prevocational evaluation was started. He was rated a permanent partial disability.

On evaluation of his physical capabilities it was found that he could lift and carry only 25 pounds, and standing tolerance was 3 hours. Total walking time was 2 hours. Running, climbing, jumping, stooping, crouching, and kneeling were all 0.

The patient had a second-year high school education. He was a steady truck driver for the past 7 years, but could not return to this occupation and was considered permanently disabled.

The patient had an I.Q. of 112, which is bright-normal. Aptitude testing showed better than average skill in arithmetic and number-checking tasks, suggesting good clerical ability and trainability.

The patient was tried out in the hospital accounting department where the foreman described his work as being usually free from error. His output was well above average. He showed eager interest in working and originality beyond the demand of his job, learned well, and made appropriate use of his knowledge. He was well liked by others, and was always congenial and cooperative.

The patient was seen by the vocational counselor, who placed him in an accounting school for vocational training. He completed a six months' course and was placed as an assistant bookkeeper at a wholesale grocery company, with a starting salary of $55 per week.

The perfection of technics to evaluate the extent of injuries is an area which is of medicolegal importance. The physiatrist then must be able to discuss the patient's medical diagnosis, evaluate his condition, and ascertain his capabilities as well as his degree of disability, if any, and render a prognosis with reasonable degree of medical certainty. He is trained clinically in long-range goals of treatment and his ability and clinical experience should enable him to make an accurate appraisal. Because of the types of diseases handled and because of his clinical training, the physiatrist is being recognized more and more as the "key" physician in handling the rehabilitation of many patients. However, this responsibility must be coordinated with and must not disrupt the role of the family physician, other consulting services, and specialties who may have a greater and more direct role to play in the therapy of the patient. Good professional relations are necessary for the patient's benefit.

C. *Rehabilitation Programs.* Workmen's compensation boards, state vocational rehabilitation agencies, insurance companies, public welfare, and social security are among the chief agencies with which good working relations must be established.

The physical medicine and rehabilitation team must coordinate effectively the skills of physiatrists, orthopedic surgeons, psychiatrists, neurosurgeons, and other physicians as well as amalgamate the special aptitudes of physical therapists, vocational counselors, occupational thera-

pists, psychologists, social workers, the staffs of rehabilitation centers, and hospital administrators. The successful management of the patients depends on the effective coordination of all these medical services. The motivation of the patient must be kept alive by a physician who is aware of the scope of the patient's rehabilitation progress and goal.

The ultimate goals of rehabilitation programs must be set and kept flexible with the patient's changes. Minimal cost to society and employers have to be gauged. Proper handling of the patient's health and future outlook must be the keystone of an effective rehabilitation program.

The statutory and governmental regulations call for some understanding of the legal scope of the problems and the roles of the various agencies. The patient presents the intrinsic medical factors. Without the patient there would indeed be a vacuum. The synthesis of the legal and medical factors make up the medical-legal aspects which were alluded to previously.

Summary

The sum total of the interrelations between the physician, patient, and other "third parties" such as hospitals, rehabilitation center staffs, insurance companies, and interested government agencies make up the medicolegal matters of which physicians in physical medicine and rehabilitation must be cognizant. Successful rehabilitation depends on an understanding and integration of these aspects by responsible physicians.

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The final test of science is not whether its accomplishments add to our comfort, knowledge and power, but whether it adds to our dignity as men, our sense of truth and beauty. It is a test science cannot pass alone and unaided.

— *David Sarnoff*

Physical Medicine and Rehabilitation: Its Responsibility and Contributions to World Understanding

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● Rehabilitation of disabled children and adults is an international language which transcends national ideological racial and linguistic barriers. It is one of America's sharpest tools for making friends. The world looks to the United States, as the international leader in physical medicine and rehabilitation, to assist it in sharing our knowledge through professional education of physicians and paramedical personnel throughout the world. This responsibility of the physiatrists of the United States has been greatly increased both by the political dangers of the current period and the rising incidence of physical disability throughout the world resulting from the prolongation of the life span. Never before, however, have the opportunities been so bright for us to meet this responsibility.

One of the distinguishing features of international relations in the past few decades is our growing recognition throughout the world that the security and welfare of one part of the world is dependent upon the security and welfare of each other part of the world.

Some of this recognition has been forced upon us by the technological advances of the twentieth century which have created a shrinking world in terms of communications, transportation, trade, and devastating effects of modern weapons of warfare. Mankind through the ages has been forced, for practical purposes, to develop social concepts to fit the realities of his changing environment.

I, for one, and I am sure this concept is shared by the great majority of people throughout the world, regardless of their race, religion, nationality or profession, believe this growing recognition of mutual dependence has not resulted from practical necessity alone, but that it also represents our ability as our society matures to give fuller expression to a feeling that is as old as mankind — the desire to share and to help our neighbors.

This concept has long been practiced by religious and private organizations, but it has been only within recent years that technical assistance programs, in which one portion of the world aids another, have been conducted by government groups. The first really global recognition of this multilateral responsibility came with the establishment of the United Nations and its specialized agencies which have placed heavy emphasis on technical assistance. In addition to these multilateral programs, various governments throughout the world have initiated bilateral programs for technical assistance outside of the framework of the United Nations.

Even the greatly increased attention to such activities through the multilateral programs of the United Nations and the bilateral programs of individual nations has not, however, filled the need which most of us feel within our minds and our hearts for increasing international cooperative activities. Consequently within the past decade there has been a great surge forward of international communication and sharing of knowledge among professions.

The highly successful international congresses of physical medicine, held in London and Copenhagen, and that to which all of us here are looking forward in Washington, D. C., in 1960, are examples of such international professional cooperation. We are motivated not only by the professional aspects of giving, receiving and sharing knowledge internationally, but we recognize that it is only through such activities that the chain of international understanding can be forged. International diplomacy and the development of international understanding cannot be solely the responsibilities of the diplomat. We as doctors share these responsibilities, and we as doctors of physical medicine and rehabilitation have special responsibilities because our particular medical specialty has given us particular opportunities.

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The people of the world have matured socially very slowly, but at the same time we have aged chronologically and physiologically very rapidly. Two thousand years ago the average person lived to be but 25; by 1900, the life span was 49; by 1950, 67; and in 1957, it reached the legendary biblical three score and ten. Today, throughout the world as a result of this extension of the life span, we have far more persons than ever before who have physical disabilities associated with aging. Added to them are the hundreds of thousands of persons whose lives have been saved at an earlier age because of medical advances through research, but who are left with severe disability.

These two parallel social phenomena of the past two decades — global interdependence and an increased incidence of physical disability — have a mutual genesis in the tremendous scientific and technological advances of this period. But there are common denominators in both the corresponding but slower development of social maturity in which the democratic societies of the world place increasing value on human worth and the human dignity of the individual.

One of these common denominators is rehabilitation of the physically handicapped.

In the developed parts of the world we have seen a remarkable growth of interest in rehabilitation in the last decade. This interest has not been prompted by humanitarian motives alone. It has resulted from the growing incidence of physical disability resulting from prolongation of the life span, increased public assistance costs because of disability, and our need for manpower in our expanding economy.

But what lies behind the interests of Indonesia, Korea, the Republic of Philippines, India, Burma and Thailand in the provision of rehabilitation services for their handicapped? It is not the need for manpower, for these nations have far more manpower than they can profitably utilize in their present stage of industrial development. It is not to reduce public assistance costs, for few of these nations have any social schemes whereby the disabled become a responsibility of the state. It is not to reduce demands for medical care, hospitalization and social services, for the chronically ill and the disabled in most of these nations are wards of their families rather than of the state.

The real reason is that many of these nations, particularly those of the Africa-Asia area, have, after years of colonization, recently achieved the long-sought dream of political independence. Now they are desperately looking for ways of proving to the world, and more importantly to themselves, that they have the political and social maturity to justify their political independence.

In the past decade, international activities in health and in rehabilitation have been an almost exclusive domain of the free nations of the Western world. Within recent months the Soviet Union has announced its intention of undertaking bilateral technical assistance activities, particularly among those nations of Africa and Asia which have declared themselves to be politically neutral, and promise upon promise of such assistance has been given by visiting Soviet officials.

It is reported that last year Russia graduated 27,000 physicians from their medical schools and 20,000 the previous year. At the present time, we are graduating slightly more that 7,000 physicians per year in the United States. It is granted that the level of education of those physicians is far below that of our physicians, but even so, the health services they are providing to the country are so superior to those ever before available to the people, it is considered a miracle.

It has also been reported that at the present time there are more doctors than can be readily absorbed in the health services of Russia and the physicians are being used for the kind of job that we would ordinarily assign to nurses and technicians. If the production continues and the excess increases, it is rather obvious what the physicians will do. They will carry the skills they have learned along with the concepts of communism to the backward parts of the world. We must meet this challenge and we can, for our physicians are better

trained. By using total professional personnel, therapists, sanitary engineers, public health administrators and educators, we can do a better job.

Fortunately, there is a growing recognition here in the United States that through medicine and particularly through rehabilitation of the physically handicapped we have a remarkably effective tool which can penetrate any Iron or Bamboo Curtain. In his State of the Union Message last January, President Eisenhower proposed a "Science for Peace" plan to "attain a good life for all." As the first step in such a program, the President invited the Soviet Union to join the current five-year program for the global eradication of malaria. The President then stated our willingness to pool our efforts with the Russians in other campaigns against cancer and heart disease. "If people can get together on such projects," he asked, "is it not possible that we could then go on to a full-scale cooperative program of science for peace?"

A very modest start toward the general objectives of the plan is already under way with the $300,000 grant made by the United States to the World Health Organization for a preliminary study to lay the groundwork for medical research on an international basis. This grant was announced by Dr. Milton Eisenhower, president of Johns Hopkins University, as the personal representative of his brother, the President, at the annual World Health Organization assembly in Minneapolis in June, 1958.

An imaginative and bold proposal to implement President Eisenhower's suggestion has now recently been introduced in the Senate by the dean of American health legislators, Senator Lister Hill, Alabama. Senator Hill has called for the creation of a National Institute of International Medical Research within the National Institutes of Health, with an annual appropriation of $50,000,000 to encourage and support research and the exchange of information on research, the training of research personnel and the improvement of research facilities throughout the world.

This program would not replace any of our current programs of multilateral international health activities through the World Health Organization or UNICEF or any of our bilateral activities conducted through the International Cooperation Administration. Instead, it would provide a mechanism and funds for uniting the sciences of the world on a greatly expanded global attack on disease and disability.

Significantly for those of us particularly concerned with physical medicine and rehabilitation, the proposal includes rehabilitation as one of the major scientific and clinical fields in which such research would be conducted.

It can be expected that Senator Hill's dramatic and far-reaching proposals will have great support. The people of the United States have demonstrated, through their willingness to contribute both tax and voluntary funds, their firm belief in the value of medical research. Most, I am confident, will also agree that while we and the rest of the world are spending billions of dollars for research for instruments of death and destruction in our struggle for survival, we should spend a few millions positively on promoting health, happiness and human understanding in our struggle for peace.

A British philosopher, 400 years ago, said this all so simply, in one sentence: "If every man would mend a man, then would all the world be mended."

An unknown Confederate soldier has said it in another way, through a prayer which has become the creed of the Institute of Physical Medicine and Rehabilitation. Several years ago, I received this prayer as a Christmas message from a distinguished American. I was deeply impressed by it and showed it to some of my colleagues and some of the patients at the Institute. One patient, after reading it, turned to another patient and said, "He is talking about us! He is talking about us." The friend read the prayer and said, "yes, he is, indeed."

The father of one of our patients who read the prayer asked that he might have it cast in bronze on a tablet to be placed in the lobby of the Institute of Physical

Medicine and Rehabilitation. It stands there today. Our patients have titled it, "A Creed for Those Who Have Suffered." In closing, I would like to share it with you.

"I asked God for strength, that I might achieve
I was made weak, that I might humbly learn to obey . . .
I asked for health, that I might do greater things
I was given infirmity, that I might do better things . . .
I asked for riches, that I might be happy
I was given poverty, that I might be wise . . .
I asked for power, that I might have the praise of men
I was given weakness, that I might feel the need of God . . .
I asked for all things, that I might enjoy life
I was given life, that I might enjoy all things . . .
I got nothing that I asked for — but everything I had hoped for
Almost despite myself, my unspoken prayers were answered.
I am among all men, most richly blessed."

Studies on the Disturbance of Longitudinal Bone Growth: II. Effect of the Sympathetic Nervous System on Longitudinal Bone Growth After Acute Anterior Poliomyelitis

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● Studies of the rate of growth of the long bones of the lower extremities have been conducted on 32 patients who had paralytic poliomyelitis involving one lower extremity primarily. Muscular strength, soft tissue mass, range of motion of the joints, posture, gait, and use of braces, crutches or canes were recorded. X-ray measurements of the bones of the lower extremities were made at intervals over a six-year period of time. The rate of growth of the involved lower extremity was compared with the rate of growth in the uninvolved extremity. Comparisons of the relative rates of growth were made during intervals when patients were receiving no medication and during the intervals when sympatholytic drugs were taken regularly. The influence of activity, limitation of motion and the use of braces are considered in evaluating the relative rates of bone growth. A relationship was found between sympathetic activity and the rate of longitudinal growth of bone which appears to have its influence through the control of the circulation to the extremity.

One of the sequelae of acute anterior poliomyelitis may be a disparity in the rate of growth of the bones of the lower extremities. This disparity in growth is usually greatest when one extremity shows severe paralysis and the other is nearly normal. However, exceptions occur frequently enough so that it does not appear that muscular paralysis is the direct or only cause of inhibition of epiphyseal growth. In a previous paper[1] it was reported that following unilateral involvement of the lower extremities by poliomyelitis, disparity of epiphyseal growth showed a correlation with soft tissue atrophy and with an estimate of muscular strength of the extremity. However, this correlation was not high enough to indicate a causal relationship.

Factors Influencing Bone Metabolism and Growth

Factors other than muscular strength may influence bone metabolism and bone growth. The stress of weight bearing as well as the stress of muscular tension influence the metabolism and structure of bone. The activity associated with walking may stimulate bone growth directly or through the effect on circulation to the bone. Walking, which is the major activity of the lower extremities, is not directly related to maximal muscular strength. If the hip and knee can achieve the normal range of extension, these joints receive major support during walking by balance and the force of gravity so that only a small proportion of the muscular strength of the hip and thigh is required for stability and motion. A patient with very severely paretic muscles can learn to ambulate adequately under these circumstances. The triceps surae supports the weight of the body on the heads of the metatarsals with each step in a normal pattern of walking. However, if the triceps surae is weak or paralyzed, walking is still possible without lifting the heel from the ground until the end of the stance phase of gait.

Any factor influencing circulation to the lower extremity may influence longitudinal bone growth. Haas[2] demonstrated that impairment of the blood supply to the epiphysis retarded longitudinal growth. Arteriovenous fistulae, either naturally or artificially produced, may increase the rate of longitudinal bone growth.[3-5] Muscular activity by the production of metabolites and by the release of heat causes vasodilatation and increases circulation through the extremity.

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This study was initiated in 1949 under a grant from The National Foundation (formerly, National Foundation for Infantile Paralysis, Inc.) and has been supported in part by research grant B-133 from the National Institute of Neurological Diseases and Blindness of the National Institutes of Health.

The dihydrogenated ergot alkaloids were supplied through the courtesy of Sandoz Pharmaceuticals, Hanover, N. J., Rudolph Bircher, M.D., Medical Director.

The mechanical pressure on the blood vessels of motion of a joint as well as the pressure of the muscle fibers as they contract will aid the capillary and venous blood flow. Stimuli to the sympathetic nervous system cause vasoconstriction which probably is greatest in the cutaneous circulation and least in the muscular circulation. Exposure to cold is one of the stimuli which produce a prolonged vasoconstriction after poliomyelitis that may seriously impair circulation to the lower extremity. In the absence of the cold stimulus, the circulation of patients who have had poliomyelitis is equal to that of normal extremities. Abramson[6] concluded that the cutaneous vessels of an extremity involved by poliomyelitis are abnormally reactive to cold. Similar findings have been reported by other workers[7-10] who reported improvement of circulation when sympathetic activity was blocked. In a previous study[11] it was found that in a small proportion of patients who had had acute anterior poliomyelitis there was evidence of an increased sensitivity of the sympathetic nervous system to a cool or cold environment, with the symptoms of painful cold feet, cyanosis of the feet, legs, and sometimes thighs; increased perspiration, and slow vasodilatation during exposure to a warm environment. In most of these patients there was moderate to severe muscular paralysis. However, the symptoms of circulatory insufficiency did not correlate directly with the muscular weakness of the various patients, and in some patients the stronger or apparently normal leg (in terms of muscular strength) would show a greater disturbance of circulation than the more paretic leg. It was demonstrated that, in a controlled cool environment, vasodilatation did not occur in these patients when exposed to reflex heating by the application of electric hot pads to the torso as would happen in a normal patient. Sympatholytic drugs, however, would cause vasodilatation in these patients in response to reflex heating in a manner similar to that of normal individuals.

It has been observed repeatedly in children with disparity in growth of leg length following poliomyelitis that the skin of the shorter leg frequently is considerably colder than that of the longer extremity.[7, 9] In a like manner, the observation of impairment of bone growth following poliomyelitis has usually been made from the northern part of North America or Europe and has been a less significant finding in warmer climates.

This study was undertaken to observe the longitudinal bone growth in children who had one lower extremity severely paralyzed by poliomyelitis and the other extremity only moderately paretic or apparently normal. The study was planned to be continued over the entire period of growth. Observations were to be made of factors influencing inhibition of growth. This report deals primarily with the effect of blockade of sympathetic activity on longitudinal bone growth.

Report of a Study: Methods

Cases Selected. Seventeen patients who have had paralysis of one lower extremity due to acute anterior poliomyelitis have been followed for periods of 13 to 91 months with repeated orthoroentgenograms for evaluation of longitudinal bone growth. Seven of these patients were girls; ten were boys. These patients varied in age at the time of onset of poliomyelitis from 3 months to 93 months with 13 of the patients under 30 months of age. Serial study of longitudinal bone growth was begun 11 months to 61 months after the onset of acute poliomyelitis. The patients selected for this study had severe involvement of one lower extremity and milder or no involvement of the other lower extremity. All patients had had treatment during the acute stage of poliomyelitis with hot packs, early mobilization, and muscle re-education. No patient wore long leg braces. Several of these patients wore some type of short leg brace because of a foot drop. All patients were ambulatory although several used Canadian crutches for walking. When the disparity of leg length was greater than 1.5 cm. a lift was added to the heel to bring the difference within that range. All patients were seen periodically for physical examination and x-ray recording of bone

growth. These patients were on normal unrestricted activity at home and in school. There was no control of the diet nor the activity of the child other than the prescription of stretching exercises to maintain mobility when necessary and to have the child attempt to participate normally in the family. Variations of health such as upper respiratory infections common in children of this age are not corrected for in this study.

Orthoroentgenography. Roentgenograms were taken of the normal and involved lower extremities using a method of orthoroentgenography similar to that described by Green, Wyatt, and Anderson.[12] Anterior-posterior roentgenograms of the lower extremities were taken on 36 by 14-inch film with the central rays of the tube directed perpendicularly to the cassette and centered successively over the head of the femur, the patella, and the talus at a tube-target distance of 40 inches. A narrow cone on the x-ray tube restricted the spread of x-rays so that there was only a slight overlap of adjacent shadows. A lead shot centered in the cone in the path of the central rays marked the impingement of the central rays on each x-ray plate to assure that parallax did not produce distortion. Each lower extremity was x-rayed individually to minimize lateral distortion while a lead plate shielded the opposite half of the film. With this technic longitudinal or lateral distortion is minimal, no greater than 5 per cent of the distance from the marked central rays to the point used for measurement. When the central focus and a bony landmark lie close together this error due to distortion is negligible. It was possible on successive x-rays to reproduce measurements within $\pm$ 1 mm. by this method. Bone and extremity lengths were read to the nearest millimeter directly from the x-ray film using a wooden meter stick or a transparent plastic millimeter rule for the measurement.

Selection of Landmarks. The selection of bony points to be used for measuring bone length was arbitrary. Throughout the period of growth the typical landmarks of the femur and tibia may change with ossification without a direct relationship to the weight-bearing length of the bone. It is desirable to measure from specific points which can be selected precisely in all x-rays. A number of points might be used satisfactorily in comparing the right against the left leg at any time in growth but over a period of years these points vary in relation to the weight-bearing length of the lower extremity so as not to provide a true picture of epiphyseal growth. It was found that the greater trochanter (fig. 1, *C*) and the medial malleolus (*H*) were unreliable points since they change in size with growth in addition to epiphyseal growth. The superior rim or limbus of the acetabulum (*A*) provides an easily determined point but changes with the angle of extension of the hip. The epiphyseal line of the greater trochanter (*D*)

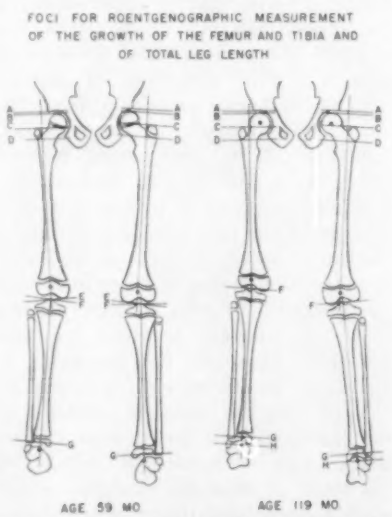

Fig. 1 — Points of reference in the lower extremities for measuring extremity or segmental length. Development of bony landmarks independently from epiphyseal longitudinal growth may mask the actual disparity of functional extremity length. *A*, superior rim or limbus of acetabulum; *B*, superior surface of head of femur; *C*, superior tip of greater trochanter; *D*, epiphyseal line of trochanter; *E*, line through the tibial intercondylar eminence perpendicular to the long axis of the femur; *F*, line through the tibial intercondylar eminence perpendicular to the long axis of the tibia; *G*, ankle joint; *H*, tip of the medial malleolus. The dot at the hip, knee, and ankle indicates the point on which the x-ray tube was centered for each orthoroentgenogram.

may be difficult to determine and does not appear to be entirely reliable. The use of the medial femoral condyle to

indicate the level of the knee produces discrepancies because of its medial position and because of variations of the valgus angle at the knee. In a paretic extremity there is less varus angulation of the neck of the femur than in a normal extremity so that measurement of femoral length to the head of the femur masks some of the shortening below the neck. In younger children, incomplete calcification of the proximal epiphysis of the tibia makes it impossible to measure tibial length from a flat tibial joint surface. After consideration of these factors three measurements were selected to represent the total and segmental lengths of the lower extremities:

1. The total length of the lower extremity was measured in a direct line from the superior aspect of the head of the femur (*B*) to the center of the surface of the ankle joint (*G*).

2. The length of the femur was measured in the line of the long axis of that bone from the perpendicular projection from the superior surface of the head of the femur (*B*) to the perpendicular projection from the tibial intercondylar eminence (*E*).

3. The length of the tibia was measured in the line of the longitudinal axis of the tibia from a perpendicular from the tibial intercondylar eminence (*F*) to the transverse line of the ankle joint (*G*).

Because of the angle of valgus at the knee, the combined lengths of the femur and tibia may vary from the measurement of total lower extremity length. From these x-rays, growth was calculated as growth per 30-day month or as growth of the involved side as a percentage of the growth of the "normal" side.

Grading of Muscular Strength. The muscular involvement of the lower extremities of these children was calculated using as a basis the study made by Beasley[13] of the muscular strength of children 10-12 years of age and the proportionate value of the manual muscle test grade of "fair." Table 1 shows the relative rating of muscular strength of each muscle group considered significant in this calculation, the proportionate value given to each grade in the standard manual muscle test, and the motor value for each muscle for each manual test grade. The proportionate value for the

Table 1: Estimate of the Proportionate Strength of a Muscle from the Grade of a Manual Muscle Test

Muscle	T.F.R.†	Lever Arm Ratio	Proportionate Value Manual Test Grade					Motor Value of Test Grade				
			1	2	3	4	5	1	2	3	4	5
Thigh												
Gluteus maximus	41	10	4	10	20	60	100	16	40	80	250	410
Long hip extensors	41	6	4	10	20	60	100	10	25	50	150	250
Iliopsoas	37	10	4	8	15	60	100	15	30	55	220	370
Tensor fasciae latae	15	6	5	15	30	65	100	5	15	27	60	90
Gluteus medius	45	5	5	15	30	65	100	11	35	70	145	225
Adductors	35	12	4	10	20	60	100	15	40	85	250	420
Quadriceps	121	12	1	2	5	50	100	15	30	60	725	1450
Inner hamstring	23	12	1	4	10	55	100	3	15	30	155	275
Outer hamstring	23	12	1	4	10	55	100	3	15	30	155	275
											Total	3765
Leg												
Triceps surae	125	2	4	16	30	65	100	22	85	160	340	530
Anterior tibial	55	1	1	2	35	70	100	1	1	19	40	55
Posterior tibial	44	1	1	3	30	65	100	0	1	15	30	45
Peroneals	56	1	1	2	35	70	100	1	1	19	55	55
Toe flexors*	60	1	2	15	30	65	100	1	10	20	40	60
Toe extensors*	25	1	2	15	30	65	100	0	4	8	15	25
											Total	770

Calculated from data of Beasley.[13]
*Calculated from other sources.
†T.F.R. = Tangent Force Reaction — force measured by strain gauge; T.F.R. × lever arm ratio = strength of normal muscle.

Table 2: Effect of Hydergine® on Relative Growth of the Paralyzed Lower Extremity

Measurement	Growth as Per Cent of Normal				
	Control		Treated		
	Per Cent	S.E.	Per Cent	S.E.	P
Total extremity length	82.9	3.1	100.1	2.4	< .0001
Femoral length	91.9	4.2	95.2	2.7	.5
Tibial length	79.5	3.8	103.8	5.1	< .0001

S.E. = Standard error of the mean.

manual test grade 3 of "fair" is based on the findings of Beasley. The other grades are arbitrarily assigned so that grade 2 is approximately 50 per cent of grade 3 and grade 1 is approximately 50 per cent of grade 2. Grade 4 was assigned a value approximately midway between grades 3 and 5. Residual lower extremity strength was calculated from the manual muscle test on the basis of this table.

Sympatholytic Drugs. The sympatholytic drugs used in this study were dihydrogenated derivatives of the ergot alkaloids, D.H.O. 180 (dihydroergocornine) or Hydergine® (an equal mixture of dihydroergocornine, dihydroergocristine, and dihydroergokryptine). Side reactions were minimal or absent in the dosage used. If the level of medication is increased enough, the side reactions consist of loss of appetite, headache, nasal congestion, epigastric pain, and, in rare patients, hypotension. The medication was administered three or four times daily as an oral or buccal tablet. The patients complained that the buccal tablet caused a bitter aftertaste. The level of medication may have been less than optimal in some cases because of limits in quantity of medication available and limits in amount of medication in each tablet. The dosage varied from 0.5 mg. three times a day to 2 mg. four times a day. Although D.H.O. and Hydergine® were administered in the same dosage, it is our impression from other studies that D.H.O. is a more effective blocking agent than the same quantity of Hydergine®.

Results

Fourteen of the seventeen patients reported here had severe paralysis of one lower extremity and normal or nearly normal strength in the other, had shortening of the involved extremity prior to the beginning of treatment, and had one or more periods between orthoroentgenograms when they were continuously on the prescribed medication. These patients therefore could act as their own controls in that growth of the "involved" lower extremity was compared to the growth of the "normal" lower extremity during periods without medication and during periods on medication. Three additional patients came in for x-ray and physical evaluation but would not take their medication at home. Interest or understanding on the part of the parents was insufficient to insure that the medication was taken. These patients have been included in the control series.

Table 2 summarizes the relative growth for these seventeen patients of the total lower extremity length, the femoral component, and the tibial component without and with treatment with the sympatholytic medication. The average observation period of continuous medication was 19 months. In only one case (5 months) was the time of observation during medication less than 12 months. In only two cases (9 and 11 months) was the observation period less than 12 months duration during the control period and the average time for the control observations was 32 months. The average age of the children at the beginning of the medication period was 84 months. The average age at the beginning of the control period without medication was 62 months. Because a period of observation was obtained prior to treatment, the average age of those in the control series is less than the average age of those in the treated series. In a number of cases, it was possible to obtain controls before and after periods of treatment. In some cases the child had reached the age where epiphyseal

closure was beginning prior to the time that a second control period could be completed.

The relative growth of the involved lower extremity expressed as per cent of growth of the normal extremity is shown in table 2 during the period without medication and during the period that the patient was taking the medication. It was found that although in the control period the growth of the total length of the involved extremity measured from the femoral head to the ankle joint was 82.9 per cent of the growth of the normal extremity, during the period of treatment the growth was identical to that of the normal extremity (100.1 per cent). The probability that this difference is random error due to chance is less than .0001.

The femur of the involved leg grew 91.9 per cent as rapidly as the femur of the normal leg during the period without treatment and 95.2 per cent as rapidly during the period of treatment. This difference is not significant ($P < 0.5$). However, the greater valgus of the femoral neck on the paretic side confuses the measurement of epiphyseal growth in the femur. The growth of the tibia of the involved leg was 79.5 per cent of the normal during the period without treatment and 103.8 per cent during the period of treatment. This difference is significant ($P < .0001$).

The mean rates of growth per month of the involved and normal legs during treatment and during the period without treatment are presented in table 3. Because of the variability of growth from patient to patient, the disparity of growth between the paretic and the normal leg is not as clearly demonstrated as when

Table 3: Rate of Longitudinal Growth of Paralyzed and Normal Extremities after Poliomyelitis without and with Treatment with a Sympatholytic Drug

	Growth per Month (Millimeters)							
	Control				Treated			
	Paretic		Normal		Paretic		Normal	
Measurement	Mm.	S.E.	Mm.	S.E.	Mm.	S.E.	Mm.	S.E.
Total extremity length	2.59	0.15	3.05	0.10	2.83	0.26	2.76	0.14
Femoral length	1.41	0.07	1.58	0.06	1.38	0.15	1.44	0.11
Tibial length	1.15	0.08	1.37	0.08	1.41	0.10	1.31	0.08

Table 4: Tabulation of Muscular Strength and Relative Rate of Growth of Lower Extremities of Seventeen Children Studied

	Muscular Strength Per Cent				Bone Growth of Paretic Leg Per Cent Normal			
	Paretic		Normal		Total Length		Tibial Length	
Patient	Thigh	Leg	Thigh	Leg	Untreated	Treated	Untreated	Treated
S. C.	6	0	100	100	....	101.6	....	116.7
M. H.	10	24	100	100	57.7	....	62.5	....
L. J.	20	24	100	100	84.3	89.4	86.5	75.9
D. J.	15	57	100	100	77.7	107.8	74.6	114.6
J. N.	31	0	100	100	77.5	....	75.2	....
M. P.	36	0	53	100	71.0	76.5	66.9	75.2
B. C.	43	2	100	100	....	94.2	....	90.8
R. C.	44	5	100	100	76.3	104.2	68.6	116.7
J. R.	41	17	72	35	90.7	95.1	79.2	141.2
J. C.	56	9	100	100	82.5	98.7	73.1	105.6
R. J.	58	19	100	100	92.7	98.3	92.8	94.2
S. B.	53	83	100	100	95.6	99.0	102.9	93.5
N. L.	75	17	100	100	....	105.5	....	95.7
D. M.	63	81	100	100	94.6	103.8	83.3	116.8
R. M.	80	26	100	100	94.0	....	84.1	....
M. S.	90	35	100	100	98.6	105.7	103.7	86.9
H. H.	97	33	100	100	90.2	103.8	90.0	128.8

the normal leg of each patient is used as the control for the paretic leg. It may be seen that during the period of treatment the mean increase in length of the total lower extremity and the mean increase in length of the tibia of the paretic leg exceeded that of the normal leg. On the other hand, during the periods without treatment, growth of the normal leg exceeded growth of the paretic leg in all segments. If comparison is made between the growth of the paretic leg during periods of treatment and during intervals without treatment it is found that the increase in total leg length and the increase in length of the tibia were greater during treatment than during the period without treatment. The probability that the increased growth of the tibia is a random error due to chance is .023. It was observed that the mean increase of total lower extremity length, of femoral length, and of tibial length for the normal extremity was less during the period of treatment than during the period without treatment. The probability that this is a random error is 0.24.

In table 4 the muscular strength and the relative rates of growth of the seventeen children are tabulated in order of increasing strength in the paretic extremity. It is apparent that during the period without treatment there is a correlation, which is not high, between muscular strength and the rate of longitudinal bone growth. During the period of treatment with Hydergine® there is no apparent correlation between strength and longitudinal bone growth.

Discussion

It has been reported by a number of investigators that during[14, 15] or following[7-11] acute anterior poliomyelitis there is increased activity of the sympathetic nervous system. Increased vasomotor tone at cool or cold temperatures, decreased circulation, cold cyanotic feet and legs, and cold wet hands and feet are the symptoms reported. Impairment of epiphyseal bone growth in a paretic extremity is also found. Sympathectomy has been reported to relieve the impaired circulation.[8-10] In approximately one half of the cases in which a paralyzed lower extremity was sympathectomized the discrepancy in length between it and the normal contralateral extremity was reduced or remained the same.[7, 16] In additional cases the rate of increase of the discrepancy was less than prior to sympathectomy.

Trott and co-workers,[17] in an investigation of the circulatory changes occurring after poliomyelitis, studied 153 children who had one paralyzed and one normal lower extremity. They reported that in the average case the coldness of the foot and leg did not develop until approximately six months after the onset of the poliomyelitis (winter) and the severely cold leg did not develop until 13 to 18 months after onset (the second winter after onset and the first winter out of the hospital). The degree of coldness was reported to be related to the amount of paralysis. In their studies of skin temperatures, which may have been carried out in a relatively warm room, the temperature of the great toe was not abnormally cold although the skin of the dorsum of the foot and the leg of the paretic extremity was colder than the normal. They concluded that "all evidence suggests that the observed coldness and circulatory changes are not a primary effect of the disease upon the sympathetic nervous system," but that the major feature is vasoconstriction due to a reflex phenomenon for which the afferent stimulus has not been demonstrated.

It has been postulated that the postpoliomyelitic response causing coldness, cyanosis, perspiration, and impairment of bone growth is an exaggerated reflex response of the sympathetic nervous system to the cold stimulus. During poliomyelitis, internuncial neurons adjacent to the sympathetic neurons in the intermediolateral columns are destroyed. This interrupts the inhibitory control from higher centers normally exerted on the sympathetic neurons. As a result the sympathetic system develops hyperactive responses to afferent stimuli such as cold. When the patient is exposed to a cool or cold environment, vasoconstriction occurs more quickly than normally, and the blood vessels relax more slowly in

response to heat. This hyperreaction to a cool environment after poliomyelitis can be demonstrated clearly in the skin of the toes, feet, and legs (fig. 2) even at moderate temperatures. As a consequence impairment of circulation to the epiphyses may be expected much of the time. If this sympathetic reflex can be interrupted, the disparity in rate of epiphyseal growth may be prevented.

In this study pharmacological rather than surgical blockade of the sympathetic nervous system was attempted. Medical therapy has several advantages. Medication may be begun early on patients likely to have a disparity in epiphyseal growth without danger or permanent loss. A long-acting tablet is easy to take. The hazards of surgery are avoided. Aberrant sympathetic ganglia[18] do not prevent the effect of treatment as may be the situation when lumbar sympathectomy is performed.

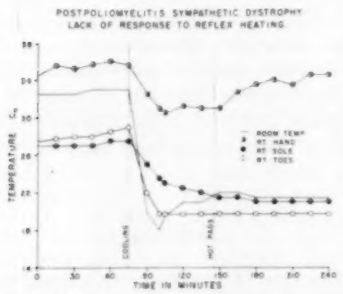

Fig. 2 — Typical sympathetic dystrophic response in a patient who has cold cyanotic feet and legs four years after poliomyelitis. In a warm room, 32 C, vasodilatation occurred very slowly in the feet and legs. When the room temperature was reduced to 20-22 C, vasoconstriction occurred with a rapid fall of skin temperature. Because of evaporation, the toe temperature fell below ambient temperature. When heat was applied to the torso with electric heating pads on abdomen and back with a heat output of 76 Cal. per hour, vasodilatation occurred in the hands but not in the feet.

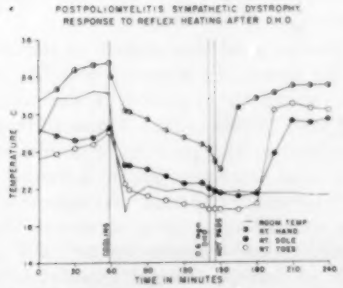

Fig. 3 — Effect of sympathetic blockade on sympathetic dystrophy following poliomyelitis. Patient and experimental conditions are the same as described for figure 2. Just prior to the application of the electric heating pads 0.6 mg. of D.H.O. was injected into an antecubital vein. Within 40 minutes after reflex heating was begun, vasodilatation occurred in the feet and legs with a rapid rise of skin temperature. This is the type of response seen in a normal individual.

On the other hand, medical therapy does have problems. Patients and parents often become negligent about a medication which must be taken regularly for many years. Side reactions may prevent the full sympatholytic effect desired. Complete blockade of sympathetic activity would result in hypotension which would incapacitate the patient during the period of the blockade. Any drug to be used over a period of years must have mild sympatholytic activity to decrease the reflex vasoconstrictor response to the cool environment and have minimal or no side effects in the dosage used. Even if the drug did not prevent vasoconstriction on exposure to cold, it should produce normal vasodilatation in response to heat.

The dihydrogenated ergot alkaloids showed these properties. There were no side effects in the dosage used. Vasodilatation occurred normally in a warm climate or in a reflex response to general heating (fig. 3). The drug could be taken orally and appeared to have a prolonged action.

In the fourteen patients treated there was not only prevention of disparity of bone growth but actually a slight overgrowth of the involved tibia (table 4). In six of these patients this overgrowth was greater than 14 per cent. There is no ready explanation for the overgrowth of the bones of the paralytic leg during the period of treatment. It is fortunate, however, that physiological adaptive processes make it possible for equilization of length to take place when the inhibitory factor is blocked. The greatest effect of sympathetic blockade was on the growth of the tibia where the major impairment occurs after poliomyelitis. In the group of children studied, the tibia on the paretic side grew only 80

per cent as fast as normal. During the period of treatment on the sympatholytic medication, the rate increased to 104 per cent of the normal side. It appears that if sympatholytic treatment is initiated immediately after the acute stage of poliomyelitis, shortening of the tibia may be avoided.

The effect of paralysis and of sympathetic blockade on longitudinal growth of the femur is more complex. In the paretic extremity the neck of the femur maintains the angle of early childhood rather than developing the more varus position of the adult. This angle may vary from 150 to 160 degrees in the young child and from 125 to 135 degrees in the adult. The angle of the neck of the femur, as well as the length of the shaft and the length of the neck, influences the functional length of the femur. This angle is difficult to measure accurately because there are no precise points of reference which remain constant throughout childhood. Slight rotation of the femur will change the apparent angle. A more valgus angle helps to mask inadequate epiphyseal growth. Because of this, attempting to evaluate the growth of the femoral epiphyses was difficult. The femur of the paretic extremity increased in length 92 per cent of the normal rate in the control period and 95 per cent of the normal rate during the period of treatment. This difference is not statistically significant. The difference of the angle of the neck of the femur on the two sides prevents the interpretation of these relative rates of increase of length as relative epiphyseal growth. If during the time of observation the angle of the femoral neck became more varus, as it does with maturation, the apparent epiphyseal growth would be less than the true growth. It is only possible to state that the sympathetic blockade did not appear to be effective in restoring the normal rate of longitudinal growth of the femur of the paretic leg after poliomyelitis.

This study does support the hypothesis that not only cutaneous vasoconstriction but also impairment of epiphyseal growth after poliomyelitis is caused by reflex hyperactivity of the sympathetic nervous system. It appears that the most important stimulus for this reflex hyperactivity is cold. In general, impairment of longitudinal growth is related to the severity of the muscular paralysis because the destruction of internuncial neurons which decreases inhibition of the sympathetic system usually is similar in degree to the destruction of neurons in the adjacent anterior horns. However, when sympathetic activity was blocked with Hydergine, which has no effect on motor neurons, motor function, or the activity of these children, the rate of longitudinal bone growth changed so that it was entirely independent of muscular strength. Discontinuance of the medication caused symptoms of sympathetic reflex hyperactivity to cold to reappear and with it the disparity in the rates of longitudinal bone growth in the two extremities.

Summary

The rate of longitudinal bone growth in the lower extremities was studied in seventeen children who had paresis of one leg and nearly normal strength in the other leg after acute anterior poliomyelitis. Over a period of one to seven years repeated orthoroentgenograms were taken and from them bone lengths were measured. The effect of the long-term administration of a sympatholytic drug, a dihydrogenated ergot alkaloid compound, on longitudinal bone growth was studied in 14 children.

It was found that growth of the tibia of the paretic leg occurred only 79.5 per cent as rapidly as growth in the normal leg after poliomyelitis. Femoral length increased at 91.9 per cent of normal rate and total extremity length increased at 82.9 per cent of normal. Treatment with the sympatholytic drug increased tibial growth in the paretic leg to 103.8 per cent of normal, femoral growth to 95.2 per cent and total extremity length to 100.1 per cent of normal.

This study is further support for the hypothesis that following poliomyelitis there is reflex hyperactivity of the sympathetic nervous system in response to cold which results in vasoconstriction in

the extremity and inhibits epiphyseal bone growth.

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The Pennsylvania Academy of Physical Medicine and Rehabilitation will meet at Harrisburg Hospital, Harrisburg, Pa., at 1:00 p.m., on January 17, 1959.

Topics for discussion are *Management of Low Back Problems; Management of the Paraplegic; Rehabilitation of the Lower Extremity Amputee; Management of Cervical Problems,* and *Physical Treatment of Shoulder Lesions.*

Address all communications relative to this meeting to J. Murl Johnston, M.D., Secretary-Treasurer, 694 Washington Road, Pittsburgh 28.

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All original articles published in the January through December, 1958 issues are abstracted in this index. See page 791.

SUBJECT INDEX

This is an index of all the reading matter in the ARCHIVES, except the Medical News Department.

The letters used to explain in which department the matter indexed appears are as follows: "ab," abstracts, "E," editorial and the asterisk (*) indicates an original article in the ARCHIVES.

This is a subject index and one should, therefore, look for the subject word, with the following exceptions: "Book Reviews" and "Deaths," are indexed under these titles at the end of the letters "B" and "D." The name of the author, in brackets, follows the subject entry. If there are more than two authors, only the name of the first author is given.

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AUTHOR INDEX

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ABSTRACTS

The following abstracted articles have been published in the January-December, 1958 issues of the journal.

JANUARY

Implications of Measured Visuospatial Impairment in a Group of Left Hemiplegic Patients. V. B. Carroll. *(pp. 11-14)*

● An analysis of errors on the Minnesota Test for Differential Diagnosis of Aphasia with left hemiplegic patients is presented in contrast with known test patterns of right hemiplegic patients with aphasia. The specific findings with the nondominant hemisphere group reveal a significant homogenous deficit in visuospatial, temporal and numerical relationships as well as a similarity in behavior responses to the observed impairment. The therapy attempted is discussed and the patient response is related to known concepts of learning theory. The implications of the residual deficits are then related to the individual vocational needs of the patient.

Comparative Study of the Effects of Tenotomy and of Denervation. C. H. Flint; K. G. Wakim, and F. H. Krusen. *(pp. 15-19; 3 figures and 3 tables)*

● In a large group of adult albino rats a comparative study at intervals up to 120 days was made of the work output, endurance, weight, and histologic structure of the muscles of the tendo achillis and the tibialis anterior in the lower extremities after tenotomy of the tendo achillis, excision of the tibial nerve alone, or complete denervation by high excision of the sciatic and femoral nerves. Excision of the tendo achillis led to gradual reduction of work output and endurance of the gastrocnemius-soleus-plantaris muscle group up to 30 days, after which there was a progressive return toward normal function. Careful dissection of the muscles at the time of return to normal function revealed complete reattachment of the excised tendon to bony eminences in the area. Tibial denervation gave unsatisfactory results. The findings were inconsistent. Complete denervation by excision of both sciatic and femoral nerves high up in the thigh was associated with consistent progressive deterioration of function, resulting in marked reduction of work output and endurance of the muscles and a histologic picture of complete denervation with marked decrease of muscle weight. The work output was practically nil toward the end of the observation period (120 days) in the muscles whose nerve supply was abolished by high excision of the sciatic and femoral nerves.

Occurrence of So-Called "Myotonic Discharges" in Electromyography. J. Goodgold, and K. C. Archibald. *(pp. 20-22; 3 figures and 1 table)*

● The occurrence of chains of high frequency oscillating electrical potentials combined with a characteristic "dive bomber" audio output is most usually associated with the classical myotonias (myotonia congenita and myotonia dystrophica). It appears rather that such characteristic potentials are most likely a manifestation of increased muscle irritability and are also seen in a variety of conditions including progressive muscular dystrophy, progressive muscular atrophy, and in various peripheral neuropathies. This study presents an analysis of the cases studied in the electrodiagnostic laboratory at the Institute of Physical Medicine and Rehabilitation in New York City along with a review of the literature and a discussion of etiological background of "myotonic" discharges.

Stair Climbing as Exercise. G. G. Hirschberg. *(pp. 23-27; 1 figure)*

● In rehabilitation, stair climbing is generally considered an activity of daily living which must be mastered. Stairs in the physical therapy department are used as "training stairs." This paper emphasizes the use of stair climbing as an exercise for weak lower extremities. Its advantages over manual resistance, pulley or boot exercises for strengthening are numerous: simultaneous exercise of several muscle groups, facilitation because of primitive pattern, economy of self exercise and group exercise. For coordination, stair climbing is simpler and more effective than Frenkel exercises and "gait training" because step width and height offer a two dimensional guide to the foot. Finally, stairs are readily available in hospitals and in most homes. Indications for stair climbing, prerequisites and technics are discussed.

Advantages of Intermediate Prosthesis in the Rehabilitation of the Lower Extremity Amputee: Preliminary Report. H. J. Bugel; W. Zilmer, and J. Grigsby. *(pp. 28-35; 2 figures and 5 tables)*

● A physical medicine and rehabilitation program utilizing an intermediate prosthesis for amputees has been successful over the past years in reducing the time interval between amputation and ambulation, with subsequent improvement in patient morale and well-being.

FEBRUARY

Rehabilitated for Living. M. Hoberman, and B. H. Lipton. *(pp. 75-81; 7 charts)*

● A review is presented of the status of graduates of the Joseph Bulova School of Watchmaking. Graduates whose disability resulted from injury or disease to the spinal cord, and those who have had tuberculosis or cardiac disease are studied. These particular individuals were selected because of the severity of the disability and the difficulty usually encountered in vocational placement.

Physical Medicine and Rehabilitation in a Chronic Disease Hospital. J. S. Tobis; M. Lowenthal, and I. Belmont. *(pp. 82-86)*

● One of the major health problems in America today is care of the chronically ill, especially the elderly patient. Physical medicine and rehabilitation offers a major contribution to the care of such patients in chronic disease hospitals, nursing homes and old age homes. This report deals with the multiplicity of services that have been developed by the physical medicine and rehabilitation department in a 2,000 bed municipal chronic disease teaching hospital. Subjects discussed include ward patient care, sheltered workshop program, prosthetic clinic, occupational therapy program for a psychiatric service, hospital-wide activities of daily living program, education and research. Of particular interest is a statistical analysis of the services provided, the active sheltered workshop program, problems in the management of young adult patients in a chron c disease set-up, accident control, and the children's rehabilitation program. A discussion of the problems encountered may assist others in dealing with patients in similar or analogous medical settings.

Physical Treatment Employed in the Rehabilitation of a Patient with Morquio's Disease. R. T. McReynolds, and O. L. Huddleston. *(pp. 87-91; 3 figures)*

● A seven-year-old boy with Morquio's disease was treated at an acute hospital for correction of progressive deformities of his trunk. Complete flaccid paralysis developed at T 11 following a spinal fusion. A partial laminectomy resulted in partial return of sensory and motor function. Bilateral fractures of the femora occurred three months later when the father attempted to teach the child to walk. During the course of treatment of the fractures, trophic ulcers developed on the back, knees, and ankles. The bones eventually healed and the patient was sent to a rehabilitation center for appropriate physical treatment. The ulcers were healed by using a heat cradle and placing the patient in a sawdust bed. Severe contractures of the hips and knees were present, in addition to the paresis and paralysis of the muscles of the lower extremities. Physical treatment in the form of neuromuscular re-education, hydrotherapy, mobilization therapy, gait training, and self-care training over a period of eleven months enabled the patient to learn to walk with the aid of crutches and long-leg braces. The vital capacity of the patient doubled by the use of breathing exercises and mobilization therapy.

Social Security for the Disabled. A. B. Price. *(pp. 92-95)*

● Determination of "disability" under the social security law provides for payments before normal retirement age, and it protects against loss of retirement and survivor benefits because of reduced earnings. An integral part of the disability program is the referral of the disabled for vocational rehabilitation services.

MARCH

Application of Rehabilitation Technics in Respiratory Insufficiency. L. Lewis. *(pp. 139-144)*

● Chronic respiratory disability is usually treated by technics applied according to the specific disease entity, not always in clear relation to the abnormal physiology which exists. There has been only limited application of the principles of rehabilitation in the management of respiratory disability. These principles would require the use of an integrated physical (respiratory assistive), pharmacologic, immunologic, psychosocial and broad medical-surgical program determined by the changing needs of the individual patient. Experience in total care of poliomyelitis patients with respiratory disability has led to a new approach to the management of other seemingly unrelated problems. Chronic respiratory insufficiency and acute crises due to pulmonary emphysema, fibrosis, atelectasis, kyphoscoliotic lung compression and many other conditions have been successfully managed by the use of any or all of the following measures: tracheostomy to diminish respiratory dead space and improve freedom of air flow; bronchodilator drugs to diminish airway resistance; mechanical respirators of many types to assure adequate ventilation and to control respiratory acidosis; oxygen to maintain an adequate partial pressure of oxygen in arterial blood; antimicrobial drugs and vaccines to eliminate infection; pneumoperitoneum to help restore diaphragm-lung relationships for effective breathing; resection of space occupying cysts or diseased lung tissue; physical and occupational therapy for general strengthening and for specific improvement of respiratory muscle function, and psychological support and social service, including vocational rehabilitation, paralleling the medical program.

An Analysis of Residual Disabilities (Paralysis and Crippling) Among 100,000 Poliomyelitis Patients: With Special Reference to the Rehabilitation of Postpoliomyelitis Patients. K. S. Landauer, and G. Stickle. *(pp. 145-151, 2 figures and 8 tables)*

● An analysis of residual disabilities among poliomyelitis patients has value for many reasons. An important one is to help determine the size and composition of the caseload of poliomyelitis patients who might benefit by further active rehabilitation procedures. The present analysis is based upon compilation and tabulation of data obtained from a series of patient-care reporting forms used by hospitals to notify chapters of The National Foundation for Infantile Paralysis, Inc., of the admission, continued care and discharge of poliomyelitis patients. More than 1500 hospitals have submitted more than 1,000,000 forms since the inception of a reporting system in 1952. Detailed case histories are available for slightly more than 100,000 hospitalized poliomyelitis patients. The reporting forms call for information on the area and degree of paralysis, as well as functional capacity, as reported by the attending physician, for each patient. It was therefore possible to make cross-classifications on disabilities, graded as none, slight, moderate or severe, in eight body areas; namely, left and right arms, left and right legs, intercostal muscles, diaphragm, abdominal muscles and trunk extensors. On the basis of a scoring system which combines degrees of disability for these specific areas of the body, it is possible to estimate percentages and numbers of paralytic patients with no, slight, moderate and severe residual disability. When these estimates are compared with reported functional capacity — ability to stand, walk, feed, toilet self, etc., — they match closely.

Morale and Productivity in a Sheltered Workshop for the Severely Disabled. H. S. Rabinowitz. *(pp. 152-157)*

● This report considers workshop climate, work habits, and personal interactions in a research sheltered shop for severely disabled, hospitalized patients before and after introduction of light subcontracting. Before subcontracting was initiated, production emphasis was given solely to handicraft projects. Introduction of subcontracts was accompanied by three changes in conditions of work. Possible connections between these changes and increases of morale and productivity are discussed.

New Apparatus: A Portable Overhead Pulley Apparatus with Adjustable Pulley Positions. L. B. Newman. *(pp. 158-159; 1 figure)*

● A portable overhead pulley apparatus which is simple, stable, inexpensive and easily constructed with standard parts is described. The equipment can also be quickly disassembled for shipping purposes.

APRIL

Paraffin Bath as Thermotherapy: An Evaluation. C. W. Stimson; G. B. Rose, and P. A. Nelson *(pp. 219-227; 7 figures)*

● The paraffin bath is an effective means of applying heat to the hands, wrists and elbows and to the feet and ankles. It is a valuable adjunct in local treatment of involved parts for such conditions as rheumatoid arthritis, osteoarthritis, tenosynovitis, and reflex sympathetic dystrophy. Contraindications for its use are impaired arterial or venous circulation, dermatitis, open wounds or heat sensitivity. The effectiveness of paraffin bath, whirlpool bath, and contrast bath in heating of an extremity is compared. A disadvantage in the past has been the difficulty in utilizing the paraffin bath for home treatment. A safe and practical way of arranging such therapy in the home is described.

Use of Cinefluorography for Evaluation of Normal and Abnormal Motion in the Neck. F. J. Kottke, and R. G. Lester. *(pp. 228-231; 2 figures)*

● A fluoroscopic intensifier system is described which makes possible the use of cinematographic recording of cervical vertebrae during motion. This apparatus exposes the patient to less radiation than does an ordinary fluoroscopic examination. The positions and relationships of the vertebrae through the full range of motion are recorded on 16 mm. film at 16 frames per second. Studies of normal and abnormal relationships are demonstrated.

Effects of Delayed Electric Stimulation on Experimentally Denervated Muscle. K. G. Wakim. *(pp. 232-234; 1 figure)*

● The effects of immediate and delayed electric stimulation were compared in an attempt to determine whether delayed electric treatment would help denervated muscle in a manner commensurate with the help afforded by immediate electric stimulation. Adult albino rats were used — normal controls and seven groups denervated by excision of a long segment of the sciatic and femoral nerves of the left extremity at the base of the thigh. At the end of the treatment period of 30 days the tendo achillis of the left leg in each rat was separated from its insertion and connected to the work output machine for determination of the initial and total work output of the gastrocnemius, soleus, and plantaris muscles. The findings clearly indicate that delayed electric stimulation did not improve the work output and endurance of denervated muscle.

Rehabilitation of the "Permanently and Totally Disabled" Patient. M. Hoberman, and C. F. Springer. *(pp. 235-240; 8 tables)*

● Preliminary results of a pilot program to rehabilitate the "permanently and totally disabled" welfare recipient are reported. The areas of improvement included self-care activities, vocational potentialities, ambulation status, and living arrangements. While these results are most encouraging, especially since the gains have been maintained in practically all patients reviewed for at least six months following discharge from the hospital, they cannot be considered final. In many instances difficulties in the patient's total adjustment encountered after discharge, such as in housing or employment, may nullify much of the benefit previously achieved.

JUNE

Some Factors Influencing the Temperature Distribution in Thighs Exposed to Ultrasound. J. F. Lehmann, and E. W. Johnson. *(pp. 347-356; 10 figures and 6 tables)*

● Thigh specimens were exposed to a uniform ultrasound field under well-controlled conditions. The temperature distribution was measured along the axis of the sound beam and the heating pattern studied with special reference to the occurrence of the selective rise of temperature in certain tissues. The factors determining the temperature elevation in the specimen such as absorption and interface reflection of ultrasound, the specific heat and heat conductivity of tissues, were analyzed and their significance for the resulting temperature distribution discussed. Also the temperature gradient in the thigh as it occurs in man and its influence on the rise of temperature resulting from exposure to ultrasound was investigated.

Effects of Breathing Exercises on Pulmonary Emphysema. J. B. Redford. *(pp. 357-365; 2 figures and 3 tables)*

● According to studies done to date, breathing exercises seem to have little objective value in emphysema but their subjective value should not be dismissed lightly. No laboratory methods are yet devised for measuring all factors that may be improved by these exercises. The main stress should be on the importance of living within the physical bounds imposed by the disease and the use of these exercises in recovery from dyspnea when these bounds are exceeded.

Ambulation Problems in Hemiplegia. E. J. Lorenze; A. J. DeRosa, and E. L. Keenan. *(pp. 366-370)*

● This is a report on 200 cases of hemiplegia resulting from a variety of etiological factors including trauma, cerebral vascular accident including hemorrhage and thrombosis, cerebral embolus and others, which were admitted to the rehabilitation service of The Burke Foundation. A specific analysis of the physical, social, psychological and vocational status of these patients is included as well as the results of rehabilitation treatment. In particular, the paper analyzes those patients who failed to achieve independent ambulation; achieved only partial independence in ambulation, or who required a prolonged period of treatment before a satisfactory degree of ambulation was achieved. Ordinary problems of a general medical nature, associated amputation, fracture or arthritis and paralytic muscular factors are evaluated. However, primary stress is not placed upon these but rather on problems of cerebellar system involvement, ataxia, apraxia, perceptual problems. The specific problems of muscular weakness and spasticity are outlined.

Bilateral Effects of Unilateral Exercise: Experimental Study Based on 120 Subjects. R. D. Kruse, and D. K. Mathews. *(pp. 371-376; 3 figures and 3 tables)*

● The purpose of this study was to test the bilateral effects of unilateral strength-building exercises on the elbow-flexor muscles. Sixty male college students were periodically subjected to ergometric exercises of the left elbow-flexor muscle group for four weeks. Fifteen subjects exercised twice weekly, fifteen three times weekly, fifteen four times weekly, and fifteen five times weekly. A control group of equivalent size was matched to each exercising group. The results of this study are: statistically significant increases in strength and endurance of the left (exercised) elbow-flexor muscles in the groups exercising three, four, and five times weekly; no statistically significant increases in strength and endurance of the left (exercised) elbow-flexor muscles in the group that exercised twice weekly; no statistically significant increase in strength and endurance of the right (unexercised) elbow-flexor muscles in any of the experimental groups, and no statistically significant increases in strength and endurance of the flexor muscles of either elbow in any of the control groups.

Swimming by the Handicapped. N. K. Covalt. *(pp. 377-380)*

● The majority of handicapped persons can learn to swim; many can be taught to get in and out of a pool with little or no aid. Since swimming is one sport that utilizes all muscles, optimal physical conditioning can be obtained or maintained. This is a step beyond definitive underwater therapy — which it can also enhance, but which is no longer needed by a rehabilitated individual. It furnishes recreation, socialization and competition.

JULY

Heidelberg Pneumatic Arm Prosthesis. E. F. Hoerner. *(pp. 411-416; 4 figures)*

● The Pneumatic Arm, devised in Germany, offers an additional asset to persons who have lost part of an upper extremity, as well as those who have a disability resulting in a flaccid upper extremity, such as quadriplegia from poliomyelitis or trauma. The principle of this orthopedic appliance is the use of carbon dioxide gas as the driving force or energy used in carrying out needed functional motions of the mechanical parts of the prosthetic apparatus. This gas is enclosed in a small cylinder which is contained within the prosthetic device. The person using such an apparatus controls the motion desired by releasing the gas outlet valve through pulling on a cable, using such movements as a shoulder shrug, shoulder flexion, intrascapular excursion, body (trunk) bending, or other similar procedures. In this way, it has been possible to provide the disabled person with the following appliance motions: prehension of the hand or terminal device, pronation and supination of the forearm (a motion that has not been possible to duplicate with any other prosthetic device), elbow flexion and extension, shoulder flexion and extension. All of these motions are performed smoothly and quickly, without a time lag, and with a mild degree of energy expenditure by the wearer. This appliance has also been found useful in assisting persons, with a flaccid upper extremity to carry out needed functional motions, by applying the energy supplied by the gas to drive the mechanical parts of an upper extremity functional arm, and/or hand, and/or shoulder brace.

Interpersonal Processes in a Respirator Center. C. P. Deutsch; I. E. Alger; E. McNamara; J. Williams; J. F. Shor, and J. G. Benton. *(pp. 417-425; 2 figures and 3 tables)*

● The purpose of this study was to investigate the quantity and quality of the continuing interpersonal process in a chronic care center. The data were gathered by means of procedures derived largely from social psychology, including structured interviews with patients and staff, daily time-sample observations, and process recording of all conferences during the period. The data were coded and the results analyzed quantitatively.

Sequence of Action of the Diaphragm and Intercostal Muscles During Respiration: I. Inspiration. G. H. Koepke; E. M. Smith; A. J. Murphy, and D. G. Dickinson. *(pp. 426-430; 2 figures and 1 table)*

● Previous electromyographic observations in the laboratory indicated that the first intercostal muscle and diaphragm were used in quiet breathing but that expiration occurred passively. A subsequent investigation has been made of the sequence of action of intercostal muscles at measured lung volumes during the various intervals of the respiratory cycle. The measurements of lung volumes were synchronized with the electromyographic activity of the intercostal muscles of normal men. The activity of several muscles was recorded simultaneously, by means of the multiple channel electromyograph using the needle technic. The evidence indicates that the intercostals were serially recruited with deeper breathing. In most instances the first intercostal muscle showed electrical activity at the onset of inspiration. As this inspiration deepened there was successive recruitment of the second through the eleventh intercostal muscles.

Influence of Arteriovenous Fistula on the Distal Circulation in the Involved Extremity. K. G. Wakim, and J. M. Janes. *(pp. 431-434; 1 table)*

● By use of the venous occlusion plethysmograph with a compensating spirometer recorder, the blood flow in the lower extremities below the knee was measured before and after induction and repair of the arteriovenous fistula of the involved extremity. After the establishment of the preoperative blood flow values, a femoral arteriovenous fistula was surgically induced in the stunted limb. At various periods after operation up to about one year, the blood flow was measured in both the normal and the operated extremity and was compared with the preoperative value. After induction of the arteriovenous fistula, the blood flow in the involved extremity in each of the seven subjects was reduced, in two of them slightly, but in the remaining five significantly. In four patients with congenital or accidental arteriovenous fistula in one of the lower extremities, a similar study was made on the blood flow before and after surgical repair of the fistula. The distal blood flow in each of the involved extremities increased on repair of the arteriovenous fistula. The presence of an arteriovenous fistula in the lower extremity reduces the flow of blood to the distal parts of that extremity.

Uses of Miniature Furniture in Aphasia Retraining. J. Ehrlich, and J. C. Cook. *(pp. 435-439)*

● Methods for evaluating the aphasic patient and planning individualized therapy, taking into consideration the educational and vocational background, as well as the type and extent of the aphasia are described. Description, purpose and use of a specific type of equipment — separate, miniature "rooms" and household objects, tools and other kinds of furnishings to scale — are given. Three case studies illustrate the uses of this device.

AUGUST

Conditions for Optimum Work Output in Elbow Flexion, Shoulder Flexion, and Grip Ergography. H. H. Clarke; E. A. Irish; G. A. Trzynka, and W. Popowich. *(pp. 475-481; 2 figures and 7 tables)*

● Use of the Kelso-Hellebrandt ergograph in single-exercise bouts of the elbow flexor and shoulder flexor muscles has been previously reported. The essential feature to achieve precision was the determination of proper load for each movement; this was found as proportionate strength of exercised muscles. For an eight-inch lever arm and with cadence of 30 repetitions per minute, the proportions were: three-eighths elbow flexion strength for elbow flexion ergography; and five-eighths shoulder flexion strength for shoulder flexion ergography. These proportions produced repeatable results, not necessarily optimum work output. The present study investigated conditions which would produce optimum work output for the elbow flexors, shoulder flexors, and gripping muscles. In each instance, experimentation was had with five cadences and five proportionate strengths, a total of 25 conditions. Exercise sessions were limited to two minutes; and the ergographic lever arm was kept constant at eight inches. Work output was the product of load in grams and cumulative distance load was raised. The optimal work output conditions were: elbow flexors, one-fourth proportion at 76 cadence; and gripping, one-half proportion at 76 cadence.

Evaluation of Rehabilitation of the Severely Handicapped Cerebral Palsied Child. A. O. Posniak; P. Saturen; J. S. Tobis, and H. M. Wallace. *(pp. 482-487; 7 tables)*

● The experience of the children's cerebral palsy unit of the department of physical medicine and rehabilitation of the New York Medical College, Metropolitan Medical Center since its inception in October, 1954, is reviewed. Based on work with 53 severely disabled cerebral palsied children, with multiplicity of intellectual and physical handicaps, an attempt has been made to assess objective functional improvement in major activities of self-care and ambulation. Criteria were set up to determine the amount of capacity to function in feeding, dressing, toileting, ambulation, and speech, on admission and at time of study. An assessment of the results of an active rehabilitation program for this severely handicapped group has been made with a discussion of the special goals that must be set, the factors which affect progress in these major areas, and the additional gains that can be seen are presented.

Pre-Vocational and Vocational Training for the Cerebral Palsied. J. E. Maschmeyer; M. H. Jones; A. Bairo; P. Holser; C. Blackburn, and S. Kupferman. *(pp. 488-493; 7 figures and 1 table)*

● In 1952 the United Cerebral Palsy Association of Los Angeles County opened its pre-vocational and vocational Industrial Training Workshop in Los Angeles. Applicants are screened by a team of specialists, and routine laboratory procedures are carried out. Applicants can be divided into two main groups namely those with potential for industrial employment, and those too severely handicapped to compete in industry. Trainees follow individualized programs directed toward fullest development of potential. Some, because of limitations, receive training only in the activities of daily living. The Industrial Training Workshop simulates actual industrial employment conditions, insofar as possible. Equipment is ingeniously adapted to the special needs of trainees. The Center is on a nearly self-supporting basis. Goals of the Center are to train severely handicapped cerebral palsied adults for self-sufficiency in activities of daily living; to train and place potentially capable cerebral palsied individuals in private industry; to determine basic standards for recognizing potentialities at an age earlier than now possible; a research program to determine the results of this "sum-total push" program is now being carried out; to determine correlation between dexterity and coordination, and future work potential. The records of this Center will furnish basic statistics in many aspects of cerebral palsy.

The Intermittent Double Step Gait. M. Peszczynski. *(pp. 494-496)*

● A gait technic and its two variations that many disabled persons use are described. In the first variation the patient tends to lose his balance abnormally during the stance phase of the disabled leg, and in the second he loses his balance during the swing phase of the involved lower extremity. The patient reacts to the shock of imbalance by pausing immediately after every other step. Because of these aberrations, characteristic and distinctive patterns result. The intermittent double step gait is a method applied successfully, and often found to be the only method, in training some of the severely disabled persons to walk independently and safely. Indications for prescribing the intermittent double step gait are discussed in detail.

Lower Extremity Prostheses for Patients Past Fifty. M. R. M. Blashy, and H. V. Morelewicz. *(pp. 497-502; 3 figures and 1 table)*

● This paper discusses the requirements which a patient must meet before any type of prosthesis can be prescribed. Included is an evaluation of the component parts that make up a specific prosthesis to meet the needs of the amputee past the age of fifty. Finally, whenever a patient needs a replacement or an additional prosthesis, what factors must be met to give the patient an adequate prosthesis are mentioned.

Some Help in the Drafting of a Physical Therapy Law. F. M. Brist, and E. C. Elkins. *(pp. 503-508)*

● A study of physical therapy laws now in effect resulted in the "guide law" prepared by the American Registry of Physical Therapists. Close study of the material presented will indicate that one provision or another may be more suitable in a given state and for that reason explanatory notes are appended to certain sections of the "guide law."

An Experimental Group Approach Supplementing Rehabilitation. I. A. Kraft. *(pp. 509-513)*

● An experimental group therapy program was instituted with parents of adult cerebral palsy patients. It attempted to test certain hypotheses about alterations of personality in cerebral palsy patients, especially those with speech handicaps.

Employability Following Poliomyelitis. M. E. Knapp, and L. Sher. *(pp. 514-518; 8 tables)*

● This paper is a statistical study of the effect of poliomyelitis upon the employability and economic status of 4,409 patients discharged from the Elizabeth Kenny Institute from 1942 through 1955. This information is correlated with the type and severity of involvement and the age at which the patient contracted poliomyelitis.

SEPTEMBER

Nutrition and Dental Care in a Physical Medicine and Rehabilitation Program. S. I. Silverman, and J. S. Tobis. *(pp. 555-559)*

● There is prevalent today a relatively widening gap between carefully planned and prepared dietary requirements of chronically ill patients and the actual ingestion of these diets. One of the major causes of this gap is the character of the dental care rendered to both the homebound and the institutionalized chronically ill patient. The quantity of food and the selection of food ingested by patients are influenced and conditioned by dental treatment and the general state of masticatory efficiency of the patient. The ingested diet is also conditioned by the social dietary history of the patients, the grouping of the patients at mealtime, the frequency of mealtime, and the availability and the character of supplementary meals. Dental care when carefully integrated in the scheme of physical medicine and rehabilitation programming can broaden considerably the base of general supportive therapy, not only in implementing nutritional treatment of the patients, but also in contributing to their speech capacity and general esthetic appearance. Thus adequate dental care, with emphasis on the prosthodontic considerations aid in the psychological adjustment of the patients in the management of their chronic illness.

Pain Threshold Measurements After Therapeutic Application of Ultrasound, Microwaves and Infrared. J. F. Lehmann; G. D. Brunner, and R. W. Stow. *(pp. 560-565; 4 tables)*

● Pain threshold measurements have been made with the Wolff and Hardy method after application of ultrasound, microwaves and infrared to volunteers. It was found that the pain threshold was increased when these modalities were applied to the peripheral nerve trunk and the pain threshold measured in the area of the nerve distribution. The pain threshold was also elevated when these modalities were applied directly to the same area where the pain threshold was determined afterwards. These results could be obtained only if comparatively high doses were applied.

Establishment of Oscillometric Clinical Norms for Arterial Circulation in the Legs in Arteriosclerotic Obstructive Disease. B. S. Troedsson. *(pp. 566-571; 2 figures and 7 tables)*

● Disability, and ultimate loss of extremities, is increasing as a result of decreased arterial circulation due to arteriosclerosis in an aging population. Early discovery and proper management at the various stages of the disease can shorten disability and prevent amputations. Because of this, it is important to be able to evaluate the degree of arterial circulation and to localize the site of obstruction. By observation and measurement on a series of cases, using the oscillometer, it is possible to establish certain clinical norms. These norms are the gangrene point, i.e., the readings below which gangrene is imminent; the ulcer healing point, i.e., the readings below which an ulcer will heal slowly or not at all; amputation site healing point, i.e., the readings above which the amputation site will heal readily; amputation site weight-bearing point, i.e., the readings above which a prosthesis can be used without fear of stump breakdown and above which there is also a margin for future deterioration of the circulation, and lower limit of normal point, or walking point, i.e., the readings below which a person will complain of symptoms of arterial insufficiency when walking. These norms have been found very useful in peripheral vascular work.

Comparative Strength of Neck Flexor Muscles in Normal and Postpoliomyelitis Children: A Preliminary Study. T. Humphrey, and D. Rubin. *(pp. 572-576; 3 figures)*

● This study was prompted by the questions what is the "normal" strength of a child's neck flexors? — is it possible to develop an objective measure for determining the degree of weakness in the neck flexors of postpoliomyelitis children? A group of 100 children between the ages of 3 and 12 was tested; 47 of this group were "normal" controls and 53 were postpoliomyelitis patients. For the purpose of the test the subjects were divided into three age categories: group A from 3-6 years, group B from 6-9 years, and group C from 9-12 years. By utilizing a fixed supine position and free active motion a base line of performance was obtained. Resistance was then added by means of an adjustable head strap, weight pan, and weights. The preliminary results demonstrated that there is a great variance in neck flexor strength in both postpoliomyelitis and nonpoliomyelitis children. Certain interesting observations were made relative to neck flexor strength within each group, between the two groups, and on the basis of body type.

Prevention and Control of Staphylococcus Infections in Hospitals. (Bulletin 1). American Hospital Association. *(pp. 577-580)*

● In view of the increasing problem of staphylococcal infections in hospitals and the consequent need to call the recommendations in this bulletin to the attention of the field, the Board of Trustees of the American Hospital Association requested this information be printed in "journals of other health organizations."

Pressure Gauge Device as an Aid in Treating Hip Contractures Following Above-Knee Amputation. T. F. Childs, and M. Holtzman. *(pp. 581-583; 3 figures)*

● A method of facilitating flexor relaxation during active extension of the hip is described. Adequate range of motion improves function with a prosthesis. Flexion-abduction contractures decrease range of motion when they occur in above-knee amputees. Flexion contracture can be prevented or stretched by active extension and simultaneous relaxation of the flexors. Abduction contractures automatically improve with improvement of flexion contracture.

OCTOBER

Trochanteric Bursitis: Diagnostic Criteria and Clinical Significance. T. P. Anderson. *(pp. 617-622; 1 figure and 6 tables)*

● A review of the literature would imply that trochanteric bursitis of the hip is rare. Most reports deal with "acute calcific bursitis." It is chronic trochanteric bursitis, a more common condition but often unrecognized because of its subtlety, for which an attempt is made in this study to provide criteria for its diagnosis. An analysis is made of pertinent factors in the history and physical examination of 45 cases. In considering whether or not trochanteric bursitis is a separate clinical entity, it is shown that in more than 50 per cent of these cases the bursitis was associated with some other painful situation in the same lower extremity or the back.

NOVEMBER

DECEMBER

vascular disease or chronic neurologic disease interferes with physical performance and what training, mechanical aids and adjustments will do for physical ability and total functional fitness. The purpose of training for the aged and handicapped is to increase their functional fitness, their ability to handle activities of daily living and management of a suitable occupation. In this instance, training is not a purpose onto itself. It should be designed to prepare for these activities on an individual basis, take maximum advantage of experience and skill, and give due consideration to psychologic factors. Thorough investigation is needed of the metabolic, respiratory and circulatory effects of exercise, of the methods, limits and goals of training, and finally a detailed study of the physiologic effects of specific daily, recreational and occupational activities in specific disabilities.

Influence of Surgical Metal Implants on the Distribution of the Intensity in the Ultrasonic Field. J. F. Lehmann; K. E. Lane; J. W. Bell, and G. D. Brunner. *(pp. 756-760; 7 figures, 2 tables and 1 equation)*

● The acoustic properties of metals used for surgical implants have been investigated, and it has been found that a large amount of ultrasonic energy is reflected at the tissue-metal interface. This leads to the establishment of patterns of standing waves in front of the implants and to focusing. The increase of intensity in the focal area has been measured and found to be appreciable. Further investigation seems to be necessary to determine whether or not the increase in intensity produced by the presence of surgical metal implants could lead to overheating of certain areas in the tissues.

Some Medicolegal Aspects of Physical Medicine and Rehabilitation. H. Wing, and A. L. Watkins. *(pp. 761-765)*

● This paper points out the ever-growing interrelationships between law and the specialty of physical medicine and rehabilitation. It is divided into three parts: 1. A brief discussion of applicable features of medical jurisprudence; 2. liability and responsibilities of physicians and other personnel of the departments within hospitals as well as legal implications of procedures and equipment employed, and 3. the insurance aspects which deal with medical reports, cooperation with statutory and administrative bodies such as Workmen's Compensation Boards, Rehabilitation Commissions, etc., and the evaluation of physical disability for purposes of litigation, settlements, or testifying in courts.

Physical Medicine and Rehabilitation: Its Responsibility and Contributions to World Understanding. H. A. Rusk. *(pp. 766-769)*

● Rehabilitation of disabled children and adults is an international language which transcends national ideological racial and linguistic barriers. It is one of America's sharpest tools for making friends. The world looks to the United States, as the international leader in physical medicine and rehabilitation, to assist it in sharing our knowledge through professional education of physicians and paramedical personnel throughout the world. This responsibility of the physiatrists of the United States has been greatly increased both by the political dangers of the current period and the rising incidence of physical disability throughout the world resulting from the prolongation of the life span. Never before, however, have the opportunities been so bright for us to meet this responsibility.

Studies on the Disturbance of Longitudinal Bone Growth: II. Effect of the Sympathetic Nervous System on Longitudinal Bone Growth After Acute Anterior Poliomyelitis. F. J. Kottke; G. G. Gullickson, Jr., and M. E. Olson. *(pp. 770-779; 3 figures and 4 tables)*

● Studies of the rate of growth of the long bones of the lower extremities have been conducted on 32 patients who had peralytic poliomyelitis involving one lower extremity primarily. Muscular strength, soft tissue mass, range of motion of the joints, posture, gait, and use of braces, crutches or canes were recorded. X-ray measurements of the bones of the lower extremities were made at intervals over a six-year period of time. The rate of growth of the involved lower extremity was compared with the rate of growth in the uninvolved extremity. Comparisons of the relative rates of growth were made during intervals when patients were receiving no medication and during the intervals when sympatholytic drugs were taken regularly. The influence of activity, limitation of motion and the use of braces are considered in evaluating the relative rates of bone growth. A relationship was found between sympathetic activity and the rate of longitudinal growth of bone which appears to have its influence through the control of the circulation to the extremity.

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PATRON

The Honorable Richard Nixon

The Vice President of the United States

PATRONESS

Mrs. Richard Nixon

Week of

August 21, 1960

WASHINGTON, D. C., U.S.A.

Preliminary information regarding this meeting may be had from the Office of the Secretary General: WALTER J. ZEITER, M.D., or from the Executive Secretary, DOROTHEA C. AUGUSTIN, 30 North Michigan Avenue, Chicago 2, Illinois.